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The BEA Quarterly Econometric Model

by

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PREFACE

Staff Papers present preliminary reports on BEA research and reports on BEA research that is more specialized or less well established than BEA research generally made available to the public.

This paper was prepared in the Econometric Studies Branch of the Business Outlook Division, Henry Shavell, Acting Chief. The authors are grateful to Fannie Hall, Irene Mattia, and Judith White, for their invaluable assistance in the preparation of this report and their efforts in the continuing work of model maintenance, development, and application. Helpful suggestions have been offered by Dr. Gorti V. L. Narasimham, who recently joined our staff. Since coauthoring this paper, Mr. Liebenberg has retired from BEA, and Dr. Green has resigned to serve as Executive Director of Wharton Economic Forecasting Associates.

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This monograph presents and describes the quarterly econometric model of the United States in use at the Bureau of Economic Analysis (formerly Office of Business Economics). The period of estimation for most equations is 1953-II through 1968-IV.^{1/}

The basic framework of an earlier version of the BEA model described in 1966 [39] is maintained in the present version. Nevertheless, a comparison of the 1966 and present models reveals considerable further development. For example, the newer version is substantially larger. It contains 63 stochastic equations, compared with 36 in the 1966 version. The increase in size is due mainly to increased endogeneity and to a lesser extent to further disaggregation. In particular, the monetary sector has been greatly expanded, and numerous tax and transfer equations have been added for Federal and State and local governments. The instruments of monetary and fiscal policy, such as nonborrowed reserves and Federal tax rates, are made more explicit. Thus, to a greater degree than in the earlier version, the design of the present model straddles the objectives of forecasting and policy analysis.

The model structure has been modified in other ways, and the specifications of almost all equations previously included have been changed. The main structural changes are as follows: First, there is now a behavioral equation for nonresidential fixed investment, in addition to two expectations-based equations. The behavioral equation is used in policy analysis, as well as in forecasting beyond the expectations horizon. Second, a different residential construction sector--a variant of that employed in the Federal Reserve-MIT model--has been introduced. Third, the labor force-employment sector has been substantially modified. Employment is now determined by an explicit function, rather than derived implicitly from man-hours and hours worked. This function, furthermore, is constrained to be consistent with the long-run production function, which yields potential output. The labor force is disaggregated into two components--one cyclically stable and the other cyclically variable. Finally, the mechanism of price determination is somewhat different from the earlier approach.

A working model is never in final form. Current and future research will result in further changes, which ultimately will make the present version obsolete. In planning future work, consideration will be given not merely to alternative specifications of existing equations, but also to more fundamental structural changes, such as possible disaggregation of production sectors. The chief criterion that will continue to guide our efforts is whether proposed changes will maintain and improve the efficacy of the whole model as an instrument for prediction and analysis.

^{1/} Since the preparation of this monograph, the model has been re-estimated using the period 1954-1971 with some tentative respecification. After further changes and a new version has been established, a revised equation listing will be made available.

Model structure

The BEA quarterly model has been designed to handle a variety of analytical problems--particularly analysis of the impact of alternative macroeconomic policies--as well as to serve as a forecasting instrument. Such a multipurpose model is almost unavoidably a "large" one, since it must contain a fair amount of structural detail. Specifically, we feel that it must involve at least broad disaggregation of final demand in real terms. Corresponding price deflators are thus needed to generate current dollar values. It should incorporate a wage-price interaction mechanism, short-run labor demand and supply functions, and equations to determine nonwage income components. Finally, it should contain fiscal and monetary equations that make policy instruments more or less explicit.

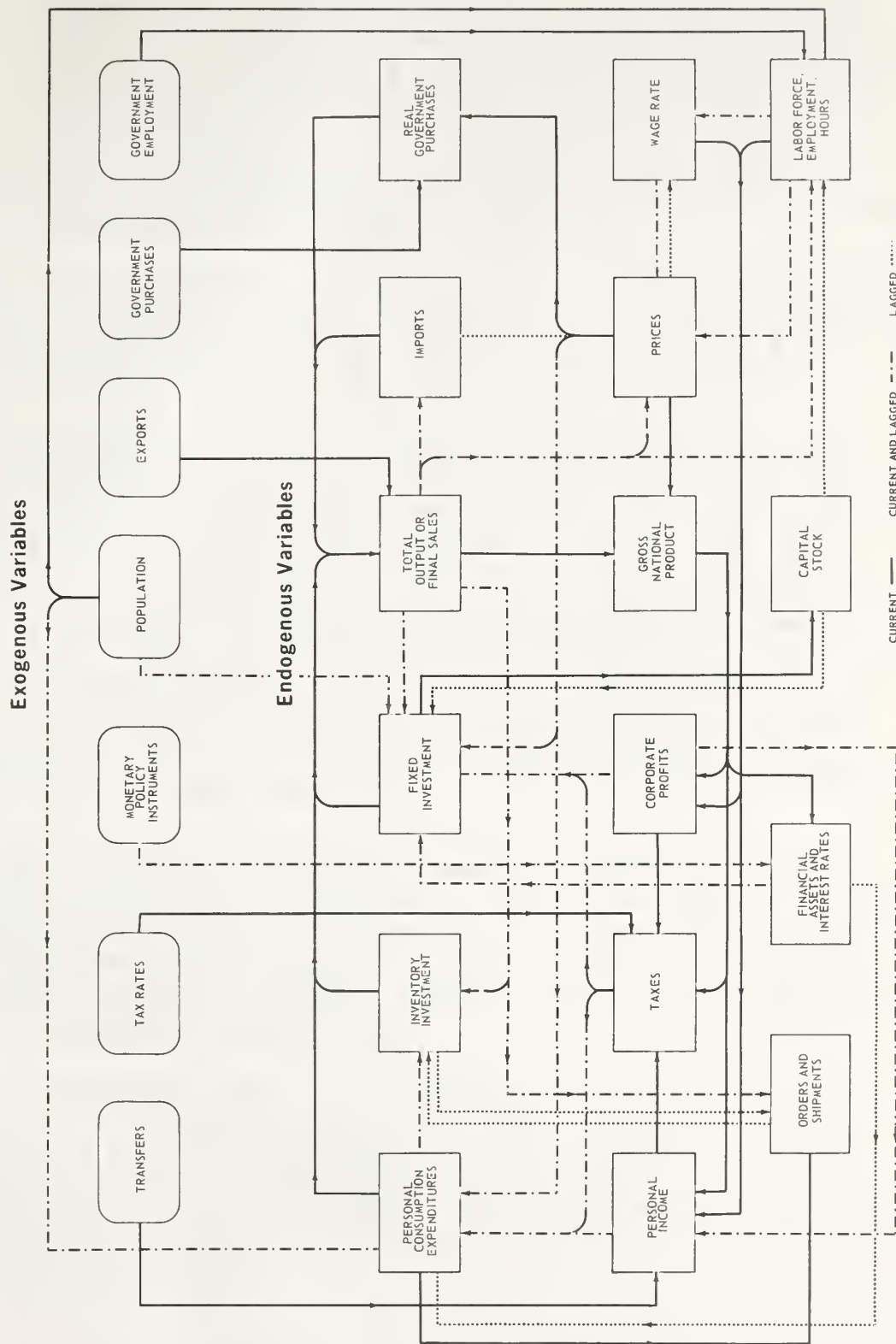
When a model is sufficiently detailed to satisfy all of these requirements, it is difficult to grasp the workings of the whole system simply by examining its equations. However, we may represent the essential features of an actual model schematically if we first mentally combine certain groups of variables and simplify somewhat the causal linkages. This is done in the accompanying flow diagram for the BEA model. The following discussion of the main causal mechanisms of the model is in terms of the diagram.

The top row of rounded boxes summarizes the main exogenous variables. The flow lines are of three kinds: (1) solid lines, which denote strictly current relationships (i.e., no lagged effects); (2) dashed lines, which indicate that the causal (outflow) variable does not affect the inflow variable during the current quarter (either a fixed delay or a distributed lag is implied); and (3) dot-dashed lines, denoting a combination of current and lagged effects.

First, let us trace the income-expenditure mechanism. The first row of boxes under endogenous variables, together with exports, which are exogenous, constitute the real final demands. These add up to GNP in constant (1958) dollars. Imports are, of course, subtracted. Current dollar government purchases of goods and services are exogenous; but because the price deflator corresponding to these expenditures is endogenous, real government purchases are endogenous.

Real output is the main determinant of employment. Employment and the average wage per employee determine wage payments, the major portion of personal income. Nonwage components of personal income--rent, dividends, proprietors' income, and interest--depend largely on current dollar expenditures (represented in the chart by GNP) and on corporate profits. Personal income is also augmented by transfers, which, except for unemployment compensation, are exogenous, and is diminished by contributions for social insurance (included in taxes). Since real disposable income is the main determinant of consumption, there are also inflow lines from taxes and prices. In the actual model there are five categories under personal consumption expenditures. Imports of services are also affected by real disposable income (not shown in the chart).

SIMPLIFIED FLOW CHART OF BEA QUARTERLY MODEL



Real output feeds back directly to fixed nonresidential investment, and final sales feed back to inventory investment. Equations for both components include flexible accelerator mechanisms, which involve output or sales and lagged capital stock. Inventory changes are also affected by the lagged change in unfilled orders and fixed nonresidential investment by cash flow (represented by corporate profits) and the long-term interest rate. Residential construction is determined--via housing starts--by population, existing housing stock, interest rates, and construction costs. Real output also directly affects merchandise imports, the largest and most volatile element in total imports. Relative import prices constitute the other explanatory variable in merchandise imports.

Fiscal policy instruments, which impinge on the income-expenditure mechanism, are represented by tax rates, transfers, and government purchases. The flow diagram indicates their points of impact. The actual model has more disaggregated components than shown in the diagram, especially for taxes.

A second important interaction mechanism is that between wages and prices. The private sector wage rate determines the price level, both concurrently and with distributed lags; prices (specifically, the deflator for personal consumption expenditures) feed back with lags to the wage rate. The main driving force of this mechanism, however, is the unemployment rate, which largely determines the long-run rate of inflation through its impact on wage changes. In turn, unemployment is derived from labor force, which is largely determined by population, and from employment, which is the sum of private employment (endogenous) and government employment (exogenous). The short-run output-employment relation determines labor productivity, which, along with the wage rate, influences price behavior. Prices, combined with real final demands, determine current dollar GNP. In most final demand components relevant prices also appear as causal determinants.

Finally, a financial sector generates various financial assets and interest rates from monetary policy instruments and transactions variables. The transactions variables are determined in the real (as distinct from financial) sector and are represented in the diagram by GNP. Interest rates feed, largely with lags, into fixed investment, both as cost-of-capital variables and as credit "availability" proxies. Household liquid assets feed with a lag into nonauto durables consumption purchases. The internal workings of the financial sector are discussed later.

As an organizational basis for a detailed description of the overall model, the latter is decomposed into twelve blocks or submodels. Each sector is treated as a quasi-self-contained entity. The behavioral equations and identities of each block and accompanying glossary of symbols are included with these discussions. The sector breakdowns correspond approximately to those available in the computer program for simulation with the model (see Green [25]).

Estimation

With a few exceptions, the estimation of coefficients in the present model is based on observations for the period 1953-II through 1968-IV. Ordinary least squares (OLS) is used as the method of estimation, despite the well-known fact that its application to a simultaneous equation model yields inconsistent estimates. We have resorted to OLS because it allows greater flexibility in model construction and modification. Moreover, there is as yet no clear evidence that consistent estimation methods are superior to OLS, given small samples and large nonlinear models.^{1/} There are other problems with consistent estimators, such as the paucity of truly exogenous variables and the joint treatment of consistent estimation, correction for autocorrelated disturbances, and distributed lag estimation.

We now turn to the latter two aspects of the estimation procedure.

When estimated in level form, many equations showed evidence of serially correlated disturbances, thus indicating inefficient estimates. In such instances we made estimates using the Cochrane-Orcutt [6] transformation, which assumes first-order autocorrelation of the disturbances. Assume an equation of the form:

$$Y_0 = \alpha_0 + \alpha_1 Y_1 + \alpha_2 Y_2 + \dots + \alpha_m Y_m + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + u,$$

where the Y's and X's are, respectively, endogenous and predetermined variables, and where

$$u = \rho u_{-1} + e, \quad 0 < |\rho| < 1.$$

The equation can be transformed to

$$Y_0 = \alpha'_0 + \alpha_1 (Y_1 - \rho Y_{1,-1}) + \alpha_2 (Y_2 - \rho Y_{2,-1}) + \dots + \alpha_m (Y_m - \rho Y_{m,-1}) \\ + \beta_1 (X_1 - \rho X_{1,-1}) + \beta_2 (X_2 - \rho X_{2,-1}) + \dots + \beta_n (X_n - \rho X_{n,-1}) + e,$$

where $\alpha'_0 = \alpha_0 (1 - \rho)$. This equation is nonlinear in the parameters. The disturbance u follows a first order Markoff process, the correlation coefficient between successive disturbance being ρ ; and e is a residual disturbance, which is assumed to be serially uncorrelated with an expected value of zero and constant variance. The transformed equations were estimated, using a general nonlinear least squares algorithm (see Marquardt [43]).

All equations that showed evidence of serial correlation, based on the Durbin-Watson statistic, were tried using the Cochrane-Orcutt transformation. Where an equation includes lagged dependent variables, the Durbin-Watson test is known to be biased. For those equations the transformation was tried in all cases. Not all transformed equations were accepted, however. Rejection was based either on nonsignificance of $\hat{\rho}$ or on a priori notions of the reasonableness of other coefficients.

^{1/} For studies pertaining to the merits of consistent estimators using small samples, see e.g., Klein [36], Mitchell [45], and Summers [57].

The assumption of a first-order Markoff decay process is in itself rather arbitrary and may not, in fact, represent the true stochastic process. Some Monte-Carlo experiments show that assuming too low an order of autocorrelation for the disturbance term can lead to rather unacceptable results (see Schmidt [53]). In the present model only first order transformations were tried.

The model contains many equations with distributed lags on explanatory variables. Many approaches have been suggested to obtain distributed lag weights in time series regressions. But all have certain limitations. Fisher's [19] arithmetic lags and Koyck's [38] geometric lag weights are early contributions. The Koyck, or declining geometric weight distribution, is a highly constrained form, not suitable for most applications. Moreover, a bias results when OLS is applied to the usual Koyck transformation because this requires use of the lagged dependent variable. A similar problem occurs with the Pascal (see Solow [55]) and the more general "rational" lag distributions (Jorgenson [34]).

Except for the Fisher distribution, all the above are lags of theoretically infinite length. An alternative is a finite polynomial lag distribution. In a substantial number of cases such lag distributions are estimated using the algorithm of Almon [1]. In general, because of multicollinearity and paucity of degrees of freedom, only polynomials of relatively low degree could be used. The Almon technique frequently requires the introduction of additional constraints, e.g., that the polynomial have a zero value at $t-k$ where $k-1$ is the order of the lag. Without such additional constraints the resulting lag structures are frequently unacceptable, usually on grounds of sign changes or unreasonable time shapes. In several instances where the Almon technique did not give satisfactory results or was difficult to apply, we resorted to preset lag structures, based on some experimentation with alternatively shaped distributions.

I. PERSONAL CONSUMPTION EXPENDITURES

Five equations explain real personal consumption expenditures. Specifically, these are demand equations for autos and parts (excluding mobile homes and trailers), nonauto durables, nondurables, nonhousing services, and housing services. Purchases of mobile homes and trailers, which have in recent years become prominent, are presently treated exogenously. Disaggregation of total consumption expenditures into these categories is warranted because time differing shapes of distributed lag in the response of consumption to income and because explanatory variables other than income are not the same for all components. In addition, the behavior of separate components, especially auto purchases, are of intrinsic interest. Some components appear as variables elsewhere in the model.

The roles of income and prices

Inevitably, disposable personal income plays a dominant role in consumption behavior. In two equations a distinction is made between transfers and other disposable income. Transfers are excluded from income in the equation for auto purchases (a reasonable assumption, considering the general nature of transfer recipients); and allowance is made for a higher marginal propensity to consume with respect to transfers, than to other income in the nondurable equation.

Disposable income is deflated by the overall consumption deflator, thereby approximating real disposable income. In those consumption equations (and only those) that do not contain an additional relative price term (all but the auto equation), the elasticity of demand is therefore the same (except for sign) with respect to the level of consumer prices as to money income. Since auto and parts purchases constitute a relatively homogeneous item, an additional relative price term does occur in the equation. Relative price terms in other consumption equations are omitted because of the high degree of aggregation over heterogeneous goods (nonauto durables, nondurables, and nonhousing services) which diminishes the meaningfulness of a relative price variable, or because of a nonsignificant relative price elasticity of demand (housing services).

Two consumption expenditures equations--those for nondurables and for nonhousing services--include a four-quarter average of lagged expenditure. This can be regarded as a variant of the simpler form: 1/

$$(I.3.1) \quad C = \alpha + \beta Y + \lambda C_{-1} + u,$$

where C is consumption expenditure, Y is income and u is a disturbance. This equation can be interpreted in two ways. On the one hand, it can be considered as derivable from:

1/ The system for numbering equations in the text is based on their relationship to estimated model equations. Thus, equations (I.3.1) and (I.3.2) can be associated with model equation (I.3).

$$(I.3.2) \quad C = \alpha' + \beta \sum_{i=0}^{\infty} \lambda^i Y_{-i} + e$$

where e is assumed to be serially independent. This is the (infinite) Koyck lag [38], with geometrically declining weights. It implies that consumption responds asymptotically to changes in income. 2/

An alternative interpretation of equation (I.3.1) is the straight-forward one: Today's consumption is partly influenced by yesterday's consumption; that is, "habit persistence" is assumed (see Brown [5]). The two interpretations are equivalent only if the stochastic terms u and e are ignored. If the u term in equation (I.3.1) is assumed to be serially independent, then the transformation given by equation (I.3.2) must necessarily imply that the disturbance e will be serially correlated. Similarly, the assumption that e is serially independent implies serial correlation of u . The data do not help us to ascertain which view is correct, but on a priori grounds we favor the habit persistence interpretation.

In the forms actually used the lagged dependent variable appears as a four-quarter average. Given this formulation, the implied lag on income is quite complicated, but under the habit persistence interpretation the treatment is acceptable on grounds of obtaining the desired inertia effects. In addition, use of four-quarter averages hedges against bias incurred when a single period lagged value of the dependent variable is used in the presence of serial correlation. 3/

Housing services per capita [equation (I.5)] is a function of (average) lagged per capita consumption of nondurables and total services. This sum is used here as a proxy for permanent income, since it embodies a distributed lag in measured disposable income. Current income effects are excluded because we believe there can be no significant response to income changes within the same quarter.

Factors other than income and prices

With the exception of the nondurables equation, the consumption equations include various explanatory variables, in addition to income and relative prices. The autos and parts equation (I.1) contains a lagged

2/ The geometrically declining weights can be associated with the permanent income hypothesis of Freidman [21], who uses such weights to obtain an approximation to the nontransient component of measured income. Strictly, however, the permanent income hypothesis requires omission of the constant term (see Evans [15, p. 24]).

3/ See Hurwicz [31]. Serial correlation can arise not only from transforming a (I.3.2) type equation, but from inadequate specification and errors of measurement.

term for auto stocks. 4/ The inclusion of the stock term implies a stock adjustment or "flexible accelerator" process. Thus, the equation can be written:

$$(I.1.1) \quad CA = \lambda (\alpha Y - KA_{-1}) + \text{other terms};$$

where Y is income, and αY can be regarded as the "desired" stock and KA_{-1} is actual stock at the end of the previous period. λ is a partial adjustment coefficient, implying that only a portion of the difference is made up in any time period. In equation (I.1) the coefficient of the stock variable has the expected negative sign.

Also included in the auto equation is average weekly hours in manufacturing (lagged one quarter). This variable, which is cyclically sensitive and a leading indicator, apparently is a proxy for consumer expectations or attitudes. It has substantial explanatory power in the equation.^{5/} There are also dummy variables to represent, respectively, the effects of strike and post-strike makeup effects on auto sales and legislation easing credit terms for auto purchases (effective since 1955).

The nonauto durables equation [I.2] contains, in addition to current real disposable income, lagged deflated liquid assets of households expressed as a deviation from an exponential trend--a form that is in rough conformity with the variable used by Zellner, Huang, and Chau [63]. Finally, since the services expenditure equations are expressed in per capita terms, they incorporate the effect of population. The per capita formulation is utilized to circumvent collinearity among population, income, and lagged consumption.

4/ Auto stocks, as used in this equation, are defined as depreciated purchases of autos and parts over the previous four years (i.e., net value of the relatively late model stock). Declining balance depreciation is assumed with the depreciation rate based on an average ten-year potential life (equation [1.7]).

5/ Some tests were made to ascertain whether the recently quantified index of the Census Bureau's Survey of Consumer Buying Intentions for autos could be successfully used in a realization function for purchases of autos and parts. Based on the realization functions tried, we have as yet no evidence that use of these data can lead to superior forecasting results.

Equations for Section I

Personal consumption expenditures, autos and parts, excluding mobile homes and trailers (1953-II to 1967-IV)

$$(I.1) \quad CA-CAH = -52.5 - 26.8 \text{ PA/PC} + .0719 \text{ (DPI-TRP)/PC}$$

(3.3) (5.0)

$$+ 1.96 \text{ HM}_{-1} - .0255 \text{ KA}_{-1} + 1.39 \text{ DCA1}$$

(5.1) (1.4) (4.4)

$$+ 1.42 \text{ DCA2} + .40 \hat{u}_{-1}$$

(1.6)

$$\bar{R}^2 = .957, \overline{SEE} = 1.02, DW = 1.98$$

Personal consumption expenditures, nonauto durables

$$(I.2) \quad CDNA = -12.0 + .111 \text{ DPI/PC} + .0997 \text{ (LH/PC)}'_{-1}$$

(99.1) (11.0)

$$\text{where } (\text{LH/PC})'_{-1} = (\text{LH/PC})_{-1} - e \quad (4.975 + .0150 \text{ T531})$$

$$\bar{R}^2 = .995, \overline{SEE} = .57, DW = .66$$

Personal consumption expenditures, nondurables

$$(I.3) \quad CN = 20.8 + .184 \text{ (DPI-TRP)/PC} + .268 \text{ TRP/PC} + .427 \overline{CN}_{-1:4} \dagger$$

(5.8) (1.9) (3.4)

$$\bar{R}^2 = .995, \overline{SEE} = 1.46, DW = .87$$

$$\dagger \overline{CN}_{-1:4} = .25 \sum_{i=1}^4 CN_{-i}$$

Personal consumption expenditures, nonhousing services

$$(I.4) \quad \text{CSNH}/N = .138 - 16.6 (1/N) + .631 (\overline{\text{CSNH}/N})_{-1:4} \\ (2.5) \quad (5.3) \\ + .0600 \text{DPI}/N \cdot \text{PC} + .45 \hat{u}_{-1} \\ (3.5)$$

$$\bar{R}^2 = .997, \overline{\text{SEE}} = .0027, \text{SE.N}(\text{CSNH})^\dagger = .50, \text{DW} = 1.69$$

Personal consumption expenditures, housing services

$$(I.5) \quad \text{CH}/N = .771 - 112.6 (1/N) + .0628 (\overline{\text{CN} + \text{CSNH} + \text{CH}})/N_{-1:4} + .94 \hat{u}_{-1} \\ (4.3) \quad (4.2)$$

$$\bar{R}^2 = .999, \overline{\text{SEE}} = .0012, \text{SE.N}(\text{CH}) = .24, \text{DW} = 1.42$$

Personal consumption expenditures

$$(I.6) \quad C = \text{CA} + \text{CDNA} + \text{CN} + \text{CSNH} + \text{CH}$$

Stock of automobiles and parts

$$(I.7) \quad \text{KA} = \sum_{i=0}^{16} .929^i (\text{CA} - \text{CAH})_{-i}$$

† Denotes standard error normalized on CSNH

I. Definition of Symbols

C	Personal consumption expenditures, billions of 1958 dollars
CA	Personal consumption expenditures, automobiles and parts, billions of 1958 dollars
*CAH	Personal consumption expenditures, mobile homes, billions of 1958 dollars
CH	Personal consumption expenditures, housing services, billions of 1958 dollars
CN	Personal consumption expenditures, nondurable goods, billions of 1958 dollars
CDNA	Personal consumption expenditures, nonauto durable goods, billions of 1958 dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
*DCA ¹	Strike dummy for auto consumption: 1956-III = -1.0, 1956-IV = 1.0, 1959-IV = -1.0, 1960-I = 1.0, 1964-IV = -1.0, 1965-I = 1.0, 1966-II = -1.0, 1967-III = -0.4, 1967-IV = -0.6, 1968-I = 1.0, 1968-II = 0.7; otherwise = 0.0
*DCA ²	Dummy for change in auto installment credit regulations: 1953-II to 1954-IV = 0.0; otherwise = 1.0
DPI	Disposable personal income, billions of dollars
HM	Average weekly hours of production workers in manufacturing establishments
KA	Stock of automobiles and parts, billions of 1958 dollars
LH	Liquid assets held by households at end of quarter (currency plus demand deposits and bank savings deposits plus savings and loan shares), billions of dollars
*N	Total population, millions
*PA	Implicit price deflator, personal consumption expenditures, automobiles and parts, 1958 = 1.000
PC	Implicit price deflator, personal consumption expenditures, 1958 = 1.000
*T531	Time in quarters, 1953-I = 1.0
TRP	Transfer payments to persons, billions of dollars

*exogenous

II. NONRESIDENTIAL FIXED INVESTMENT

Three alternative equations--(II.1) to (II.3)--are shown for gross private nonresidential fixed investment. The first explains investment outlays in terms of decisional determinants. The other two are "realization" functions, based on expected outlays given in the BEA (formerly OBE-SEC) Plant and Equipment Expenditures Survey.

Realization functions have been shown to forecast better than equations that relate outlays directly to basic determinants of investment decisions (see e.g., Friend and Thomas [22]). However, they can only be applied to the relatively short forecasting horizon for which expectation data are usually available. Moreover, an unexpected change in the economic environment can affect the level of investment within the forecasting horizon in ways not accounted for by the realization equations. For both reasons, a complete model requires either an equation to explain expectations as, for example, in the Brookings model (Duesenberry, *et al.* [11, chs. 2 and 3]), or one or more equations relating investment expenditures to causal determinants. We follow the second approach.

Investment as a function of decision variables

A great variety of investment functions may be found in econometric literature and in econometric models. 1/ Despite a considerable overlap in content among such functions, there is as yet no consensus as to which variable should be included and the form in which they should be specified. This reflects primarily disagreement about the nature of the underlying production function and a lack of knowledge about how short-and long-run expectations affecting investment decisions are formed. 2/ The differences in specifications are even more critical for the analysis of policy impacts than for forecasting (see Fromm [23]). Moreover, while it is universally agreed that the decision variables affect investment behavior with lags distributed over many quarters, there is great variation in the precise time shapes of these lag distributions.

We have experimented with a number of substantially different functions, including that of Bischoff [3] (which is based on the neoclassical approach of Jorgenson [33]) and models devoid of a neoclassical production function constraint. Such functions were tested both in terms of single-equation criteria and in the context of the full model within and beyond the sample period.

1/ For a survey of investment functions, see Jorgenson [33].

2/ A corporate stock price index or price-earnings ratio is sometimes used as a proxy variable for expectations; but in the context of a complete equation system this only begs the question, since the proxies themselves require explanation. On this and other problems, see Eisner [13].

While other functional forms have much to commend themselves, we have tentatively settled on the structure proposed by Almon [2]. The basic structure is simple and performed relatively well in post-sample tests. Investment decisions are a function of expected output (for which current and past outputs are proxies), capacity output, cash flow, and the supply of external funds (as reflected by long-term bond yields). In the Almon specification investment decision variables explain (with suitable lags) appropriations for capital expenditures. Since appropriations, rather than expenditures, are explained, another function is required to translate appropriations into expenditures.

Doubts about the appropriateness of the nominal rate of interest in an investment function have been raised by strong investment in the late 1960's, despite historically high nominal interest rates. The observed high yields were accompanied by strong inflation and, consequently, expectations of continued inflation. Such expectations are projected into the expected nominal rate of return (i.e., they increase expected net revenue relative to that when inflationary expectations are absent); thus they tend to offset the higher nominal interest rate in its deterrent impact on investment.

We have thus supplanted the nominal interest rate, used by Almon with the nominal rate less the four-quarter percent change in the private GNP deflator--a crude proxy for expected price change. The resulting "real" interest rate has somewhat stronger explanatory power than the nominal rate, though the t-ratio remains less than two. However, tests with truncated regressions ending in 1966-III, using nominal and real interest rates, show considerable superiority for the real variant for the post-sample period.

Realization equations using BEA expectations data

Equation (II.2) is the realization equation that uses expected expenditures for the current quarter, as indicated by responses to the Plant and Equipment Survey, conducted early in that quarter (i.e., "one-quarter ahead" expectations). The equation, which explains actual expenditures on a national income and product accounts basis, is in relative change form. The change term for expectations is expressed as the ratio of expected to lagged actual expenditures, the latter being Survey-based expenditures of the previous quarter. Equation (II.3) is the comparable "two-quarter ahead" realization function. In this equation the main "explanatory" variable is the relative change in expected expenditures from one quarter to two quarters ahead.

Since unanticipated changes in the economic environment can modify investment behavior from stated expectations more readily in two quarters than in one, it is appropriate to use different realization functions that reflect this difference. Thus, there is a change-in-output term in (II.3), but not in (II.2); when tried in the latter, it was found non-significant.

The equation based on two-quarter ahead expectations (II.3) also makes allowance for the revision of expectations in the previous quarter, that is the difference between one-quarter and two-quarter expectations for quarter $t-1$. This term has a positive coefficient, which is meaningful if successive two-quarter expectation errors are positively correlated, and the revision of expectations tend to represent an adjustment toward actual expenditures. ^{3/} The appearance of consumer auto purchases in both equations with the pre-assigned parameter 0.176 reflects the estimated distribution of auto sales between consumer and business use. The Survey series does not include the bulk of such purchases.

The last equation (II.4) yields the net stock of plant and equipment. The average quarterly depreciation rate of .0264 is derived from BEA's "Fixed Business Capital" Study [20], using the straight line depreciation, constant cost I net stock variant.

^{3/} We also tried in each realization equation past expectations errors, i.e., the difference between lagged expected and actual expenditures, but these terms proved to be nonsignificant in both cases.

Appendix: Estimation of Equation (II.1)

The distributed lag weights are not estimated directly, but are derived from Almon's separate estimates of the distributed lags from plant and equipment appropriations to expenditures and from investment decision determinants to appropriations for the manufacturing sector. The set of lag weights for the first relationship is taken from Almon's [1] regression of BEA Survey-based expenditures in manufacturing on adjusted Conference Board (formerly National Industrial Conference Board) appropriations. The lag weights representing the investment decision process are derived from one of Almon's [2] regressions of the general equation:

$$(II.1.1) \quad \frac{A}{XMP} = \beta_1 + \sum_{j=0}^{n_1-1} w_j \frac{XM_{-j}}{XMP} + \sum_{j=0}^{n_2-1} w'_j \frac{CFM_{-j}}{XMP} + \sum_{j=0}^{n_3-1} w''_j \frac{RL_{-j}}{XMP} + u.$$

This equation relates appropriations (A) to the industrial production index for manufacturing (XM), internal funds (CFM), the average bond yield (RL), and a capacity output index (XMP). Current rather than lagged capacity appears since it is assumed that firms anticipate their capacity with reasonable accuracy. Both sets of distributed lag weights were obtained by Almon using the procedure for fitting polynomial lag distributions, which she presented in [1].

The distributed lag weights from the two functions are combined to yield a single set of reduced-form weights for each variable. As a result, investment expenditures are a direct function of the decision variables. Consider first the appropriation-expenditure lag:

$$PEM = \sum_{i=0}^k v_i A_{-i},$$

where PEM represents actual plant and equipment outlays in manufacturing. Dividing both sides by capacity, this becomes:

$$(II.1.2) \quad \frac{PEM}{XMP} = \frac{1}{XMP} \sum_{i=0}^k v_i A_{-i}.$$

Substituting (II.1.1) in (II.1.2), we get:

$$(II.1.3) \quad \begin{aligned} \frac{PEM}{XMP} = & \frac{1}{XMP} \sum_{i=0}^k v_i \beta_1 XMP_{-i} \\ & + \frac{1}{XMP} \sum_{i=0}^k v_i \sum_{j=0}^{n_1-1} w_j XM_{-i-j} \\ & + \frac{1}{XMP} \sum_{i=0}^k v_i \sum_{j=0}^{n_2-1} w'_j CFM_{-i-j} \\ & + \frac{1}{XMP} \sum_{i=0}^k v_i XMP_{-i} \sum_{j=0}^{n_3-1} w''_j RL_{-i-j} \\ & + \frac{1}{XMP} \sum_{i=0}^k v_i XMP_{-i} u_{-i}. \end{aligned}$$

If we take XMP_{-i}/XMP to be essentially fixed at β_{2i} , (II.1.3) reduces to (II.1.4), as follows:

$$\begin{aligned} \frac{PEM}{XMP} &= \beta'_1 + \frac{1}{XMP} \sum_{i=0}^k \sum_{j=0}^{n_1-1} v_i w_j XM_{-i-j} \\ &+ \frac{1}{XMP} \sum_{i=0}^k \sum_{j=0}^{n_2-1} v_i w'_j CFM_{-i-j} \\ &+ \sum_{i=0}^k \sum_{j=0}^{n_3-1} \beta_{2i} v_i w''_j RL_{-i-j} + u^i, \end{aligned}$$

where $\beta'_1 = \beta_1 \sum_{i=0}^k \beta_{2i} v_i$ and $u^i = \sum_{i=0}^k \beta_{2i} u_{-i}$.

The final step is to apply these results to the national income accounts data, in place of the manufacturing sector data used by Almon. The tabulated weights w , w' , and w'' represent the combined weights derived from v_i , w_j , and β_{2i} in equation (II.1.4). These determine the relative distribution of lagged weights in the final function. The regression coefficients, obtained by us, then serve appropriately to scale up or down the sum of weights.

Admittedly, the application of distributed lag weights obtained from the manufacturing sector to the whole private economy is hazardous. However, it seems more hazardous to attempt to estimate three different sets of distributed lag weights directly in the reduced-form equation. This is true, particularly when each lag structure is too complex to be captured by a polynomial of degree no greater than three.

Equations for Section II

Nonresidential fixed investment (based on endogenous variables only)

$$\begin{aligned}
 \text{(II.1)} \quad (\text{ISE} - .176 \text{ CA}) / \text{XP} = & \underset{(1.5)}{.0284} + \underset{(2.9)}{.0541} \left(\sum_0^{11} w_i X_{-i} \right) / \text{XP} \\
 & + \underset{(1.1)}{.00179} \sum_0^{11} w'_i \left\{ \text{RL} - 100 \cdot \left[(P - P_{-4}) / P_{-4} \right]_{-i} \right\} \\
 & + \underset{(3.9)}{.426} \left(\sum_0^{11} w''_i \text{CF}_{-i} \right) / \text{XP} + .89 \hat{u}_{-1}
 \end{aligned}$$

$$\text{where } \text{CF} = \frac{\text{CP} + \text{DC} - \text{TCF} - \text{TCSL}}{(\text{PISE} \cdot \text{ISE} - \text{TCRI}) / \text{ISE}}$$

<u>i</u>	<u>w</u>	<u>w'</u>	<u>w''</u>
0	.622	-.151	.027
1	.984	-.259	.068
2	.830	-.267	.109
3	.348	-.200	.138
4	.009	-.138	.145
5	-.209	-.086	.133
6	-.330	-.042	.155
7	-.403	-.004	.090
8	-.439	.028	.064
9	-.485	.068	.035
10	-.307	.049	.016
11	-.108	.018	.004
Σ	.593	-.984	.984

$$\bar{R}^2 = .960, \overline{\text{SEE}} = .0020, \text{SE.N(ISE)} = .89, \text{DW} = 1.82$$

Nonresidential fixed investment (based on BEA Plant and Equipment Expenditures Survey, one quarter ahead)

$$(II.2) \quad \Delta \log (ISE-.176 CA) = \begin{matrix} .00002268 \\ (.018) \end{matrix} + \begin{matrix} .637 \\ (6.9) \end{matrix} \log \left[(ISE1Q/PISE) / (ISEA/PISE)_{-1} \right]$$

$$\bar{R}^2 = .429, \overline{SEE} = .00872, SE.N(ISE) = .94, DW = 2.03$$

Nonresidential fixed investment (based on BEA Plant and Equipment Expenditures Survey, two quarters ahead)

$$(II.3) \quad \Delta \log (ISE-.176 CA) = \begin{matrix} .000267 \\ (.19) \end{matrix} + \begin{matrix} .227 \\ (2.3) \end{matrix} \log \left[(ISE1Q/ISE2Q)_{-1} \right] \\ + \begin{matrix} .804 \\ (5.8) \end{matrix} \log \left[(ISE2Q/PISE)/(ISE1Q/PISE)_{-1} \right] \\ + \begin{matrix} .356 \\ (2.1) \end{matrix} \left[\log (X/X_{-1}) - .25 \log (X_{-1}/X_{-5}) \right]$$

$$\bar{R}^2 = .404, \overline{SEE} = .00892, SE.N(ISE) = .92, DW = 1.77$$

Net stock of nonresidential fixed capital

$$(II.4) \quad KSE = .9736 KSE_{-1} + .25 ISE$$

II. Definitions of Symbols

CA	Personal consumption expenditures, automobiles and parts, billions of 1958 dollars
CP	Corporate profits and inventory valuation adjustment, billions of dollars
*DC	Corporate capital consumption allowances, billions of dollars
ISE	Nonresidential fixed investment, billions of 1958 dollars
*ISEA	Actual expenditures, BEA Plant and Equipment Expenditures Survey, billions of dollars
*ISE1Q	Expected expenditures one quarter ahead, BEA Plant and Equipment Expenditures Survey, billions of dollars
*ISE2Q	Expected expenditures two quarters ahead, BEA Plant and Equipment Expenditures Survey, billions of dollars
KSE	Net stock of nonresidential structures at end of quarter, billions of 1958 dollars (Constant Cost I, average life = 85% of Bulletin F)
P	Implicit price deflator, private nonresidential output, 1958 = 1.000
PISE	Implicit price deflator, nonresidential fixed investment, 1958 = 1.000
RL	Corporate bond yield (Moody's) percent
TCF	Corporate profits tax liability, Federal, billions of dollars
*TCRI	Investment tax credit, billions of dollars
TCSL	Corporate profits tax liability, State and local, billions of dollars
X	Private nonresidential output, billions of 1958 dollars
XP	Potential private nonresidential output, billions of 1958 dollars

*exogenous

III. RESIDENTIAL CONSTRUCTION

Equations relating to residential construction outlays have been among the most troublesome in econometric models. Development of a "good" housing submodel has been hampered by inadequate theory, data deficiencies, and the disparateness of local or regional housing markets. In recent years the behavior of the housing market has been further complicated by the significant growth of mobile homes and the role of Federal subsidy programs. Future equations will have to take these phenomena into account.

The housing sector in the present model is a variant of that developed by Gordon Sparks and modified by the Federal Reserve Board for inclusion in the Federal Reserve-MIT model (see deLeeuw and Gramlich [8, pp. 17-18] and [9, pp. 467-69, 482-83]). A condensed scheme for this sector is presented in the accompanying flow chart.

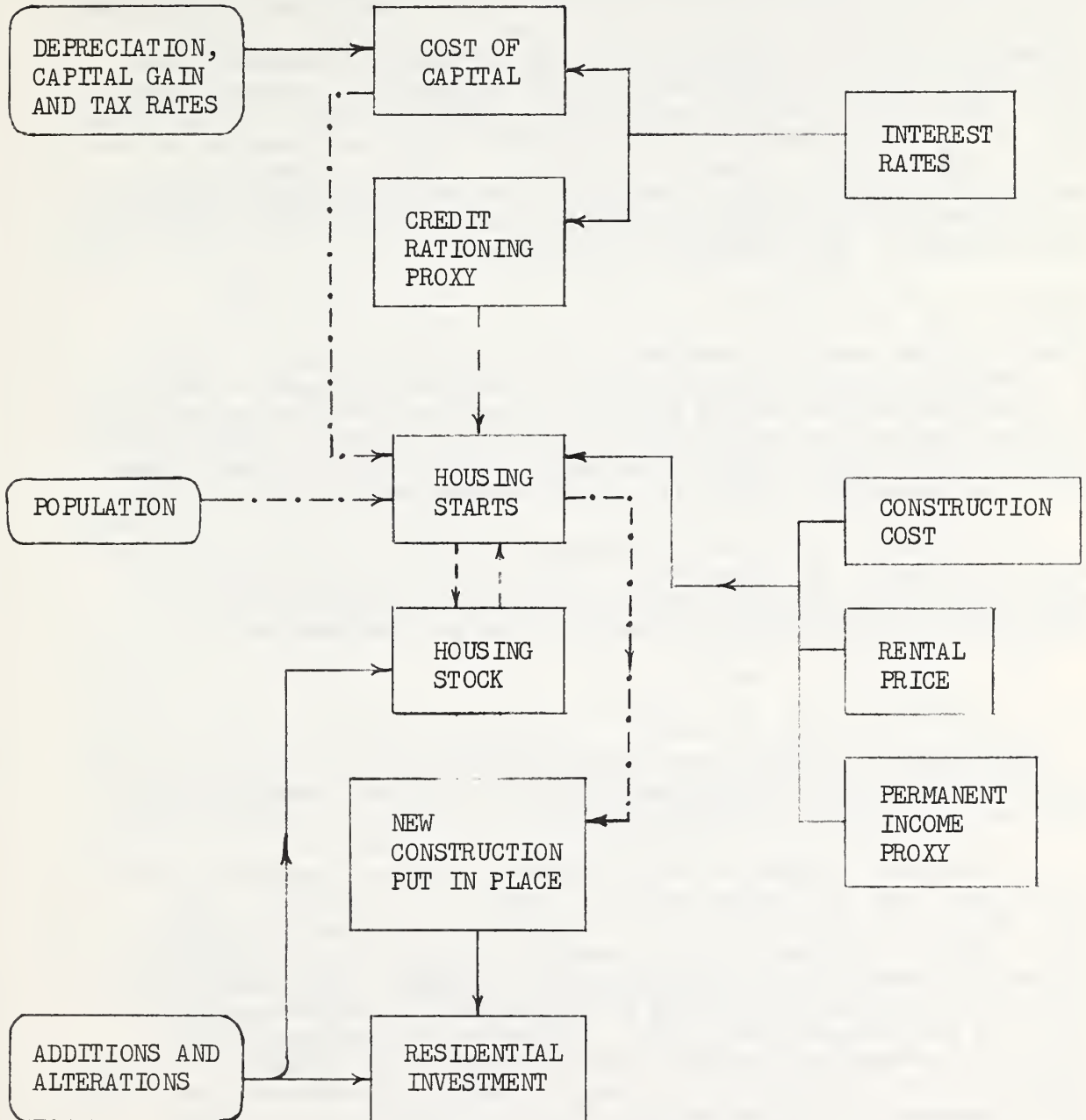
The key variables in this sector are single- and multifamily housing starts. The endogenous variables of the full model, which help to determine starts, are construction cost, rental price (multifamily starts), "permanent" income (single-family starts), and interest rates. Interest rates act directly on starts via the cost of capital and indirectly through a credit rationing or "availability" proxy. Population is the main exogenous variable affecting starts. Completions of new units (lagged starts) add to the housing stock which, in turn, has a dampening impact on future starts. Starts are translated into new construction, which together with additions and alterations and transactions margins on existing residential structures, yield total residential investment.

In adapting the Federal Reserve-MIT housing sector for inclusion in the BEA model a number of changes were made: Specifically, somewhat different interest rate variables in the cost of capital expression and different proxies for permanent income and credit availability are used. Also, the lag structures were re-estimated and differ from those found in the FRB-MIT model. The housing sector was tested against that used in earlier versions of the BEA model and appears to be superior.

SIMPLIFIED FLOW CHART FOR RESIDENTIAL CONSTRUCTION SECTOR

EXOGENOUS
VARIABLES

ENDOGENOUS
VARIABLES
(OTHER SECTORS)



— current
- - - lagged
- . - . - current and lagged

Equation (III.3) is the form of the relationship used to estimate the value of one- and two-unit housing starts (HS1). The structural relationship underlying the estimated (reduced form) equation can be written as:

$$(III.3.1) \quad \frac{HS1}{N1 \times PHC} / Ae^{\rho t} = e^{\alpha_0} \left(\frac{PKH1}{PHC} \right)^{\alpha_1} CR^{\alpha_2},$$

where PKH1 is an unobserved housing asset price; PHC, an index of construction costs; CR, a credit rationing variable; $Ae^{\rho t}$, a trend meant to depict per capita productive capacity in the one- and two-family housing subsector with the rate of growth of such capacity equal to ρ ; and N1, the adult population (aged 25-65) expected to live in single-family dwellings. In this form it is seen that the value of starts depends on (relevant) population, the ratio of prices to construction costs, and credit availability. Since the asset price of one- and two-family units is not observed, it must be translated into observable quantities. This is accomplished by two successive substitutions. Accordingly, two more equations are required. The first relates the implicit rental price to the asset price and the cost of capital. This equation can be written:

$$(III.3.2) \quad RH1 = PH1/PKH1 = (RD - RG) + (1 - RTP) (RIN + RTRE),$$

where RH1 is the cost of capital for one- and two-family housing units; PH1 represents the implicit rental price of one- and two-family units; RD is the rate of depreciation and RG the expected rate of capital gains; RTP is the personal tax rate; RIN represents an appropriate interest rate; and RTRE is the average property tax rate. Since realized capital gains on sales of houses are largely tax exempt, no modification of RG is used.

This equation represents an equilibrium condition. When the cost of capital (the sum of the terms on the right hand side of the equation) is equal to the ratio of rental price to asset price, households will (theoretically) be indifferent between renting and home ownership. ^{1/}

^{1/} The equation is derivable from the more general expression for the costs of capital given in Jorgenson [33]. The equation given here omits terms that do not apply to housing capital.

In computing the cost of capital, average rates of depreciation and capital gains over the postwar period on housing, including land, were used. The annual depreciation rate is taken as 2.7 percent for houses. Capital gains are assumed to be 1.6 percent for houses and 10 percent for land, with weights of 0.8 for houses and 0.2 for land. The interest rate term is computed by assigning a weight of 0.7 to the mortgage rate and 0.3 to the corporate bond yield. The weights are obtained on the basis of an average loan-to-value ratio to reflect both the cost of borrowing and an implicit return on owner's equity. The property tax rate is computed by dividing receipts from such taxes by the estimated current dollar value of the housing stock, including land.

Equation (III.3.2) again contains an unobserved variable, namely the implicit rental price (PHI). An equation for rental price is derived from the equilibrium of supply and demand for rental space, which is the second of the two needed relationships:

$$(III.3.3) \quad KH1/N1 = e^{\beta_0} (YP/N)^{\beta_1} (PH1/PC)^{\beta_2},$$

where KH1 is the single-family housing stock; YP represents permanent income ^{2/}; N is total population; PC is the price index for personal consumption expenditures.

This relationship equates the supply of housing services, represented by stock of houses, to demand variables, namely permanent income and relative prices. In the short run the stock of houses is essentially fixed so that the equation determines the implicit rental price.

Equation (III.3) is obtained by first replacing RH1 and PH1 by their derived functional expressions, then substituting them in equation (III.3.2) to yield an expression for PKH1. Different lags in response to each of the variables in the final equation are allowed for.

The lag structures in the estimated equation suggest that the response to a change in cost is relatively slow and of long duration, while that for the cost of capital variable is relatively fast. Although the estimated responses differ from those used in the Federal Reserve-MIT model, they are similar in general profile and indicate that a rise in the cost of capital results fairly quickly in postponement of housing starts, while a similar rise in relative price initially has little effect. These time shapes indicate, respectively, "regressive" and "extrapolative" expectations, in accordance with a priori belief.

The credit variable used in the regression equations for the values of both one- and two-family and the multifamily housing starts is designed to capture the effects of credit rationing on housing construction, as distinct from the cost of borrowing. It is defined by an equation, which is a nonlinear function of the spread between long- and short-term interest rates. ^{3/} When the long rate (represented by the bond yield) exceeds the short (commercial paper) rate by more than one percent, CR is defined as zero. Therefore during periods of monetary ease variations in the spread have no impact. As the spread becomes small, CR = $[1 - (RL - RS)]^2$ becomes large and exceeds unity in periods of very tight credit, when the short rate exceeds the long rate.

^{2/} Lagged per capita consumption of nondurables and nonhousing services is used as the permanent income proxy in equation (III.3).

^{3/} This is a variant of a variable used in the Data Resources, Inc. model.

CR was substantially positive during 1956-57, late 1959 to early 1960, 1965 to early 1967, and occasionally during 1968-70. It exceeded unity during the last three quarters of 1966 and 1967-I, when it was much larger than any other time in the postwar period and coincided with the credit "crunch" of that period. This variable is preferred to one involving specific institutional deposit flows because such flows would have to be predicted and because the financial support structure for housing has shifted substantially over the sample period.

The same approach is used to estimate the value of multifamily housing starts [equation (III.4)]. In this case, the derivation of the reduced form is simplified by using an explicit rental index, instead of the implicit rental value set forth in equation (III.3.3). However, a separate function for rental price is required and is listed as equation (IX.6) in the price sector of the model.

The cost-of-capital expression used for multifamily units also requires modification in that capital gains and rents are fully taxable and owners are permitted to use accelerated depreciation. In addition, a somewhat longer life is assumed for multifamily dwellings, and a different weighting of the mortgage and corporate bond yields is used to take account of the fact that the loan-to-value ratio is higher for such dwellings.

Unlike the equation used for single family housing starts, the multifamily function contains the additional term $1/(KH3 - 60.0)$, where KH3 is the stock of multifamily dwellings. This term is purely empirical; hence the housing stock (KH3) has no causal significance. When the stock grows, the variable becomes smaller, approaching zero in the limit. The parameter 60.0 was chosen to yield a leveling off in the early 1960's. As can be seen from an examination of the reduced form given in equation (III.4), the variable enters with a negative sign, and hence smaller and smaller amounts are subtracted from the dependent variable, as growth in stock continues.

The use of this quasi-logistic variable is justified on the ground that it reflects a "learning" process, particularly related to the liberalization of depreciation allowances on this type of investment in the Revenue Act of 1954. Taken by itself, the variable reveals a positive stock effect. However, the equation for the housing services deflator (rent index proxy) contains the stock variable with a negative coefficient. After the early 1960's, this effect dominates the positive impact, due to the logistic term.

The housing starts equations are estimated only for the period since 1957-IV. Going backward from 1959, starts data are of increasingly poorer reliability. Before 1957 multifamily starts, moreover, were at very low levels and displayed little variation. Attempts to estimate the equations for the full model sample period did not yield satisfactory results.

The single and multifamily housing stocks are given in equations (III.7) and (III.8). These are based upon assumed depreciation rates, completion times for each kind of unit, and an approximate average distribution of additions and alterations between the two categories.

Since the basic construction variable determined by the model is starts, a phase-out relation is required to translate starts into expenditures (construction put in place). Equation (III.5) represents this translation; the distributed lag weights are based on the Census Bureau's formula. ^{4/} Additions and alterations are added exogenously to obtain total residential outlays.

Because the housing starts equations are estimated only for the period after 1957, equation (III.6) estimated over the full sample period, is included as an alternative so that the model as a whole can be simulated over the entire sample period. This equation directly explains per capita housing construction expenditures as a function of lagged rent-to-cost ratios and the spread between long- and short-term interest rates.

^{4/} This is the single aggregative formula used by the Bureau of the Census until recently. The disaggregative formulas presently in use by the Bureau have not been incorporated in the present model.

Appendix: Estimation of Housing Starts Equations

One- and two-family units. The theory underlying equation (III.3) requires that the steady-state elasticities of starts with respect to relative price and cost of capital are the same but have opposite signs. Similarly, on the basis of results obtained in some housing studies, we impose the condition that the elasticities of both housing stock and the permanent income proxy also be the same but have opposite signs.

The first constraint requires that the sum of the distributed lag weights for both relative price and cost of capital be the same, but it allows the corresponding individual lag weights of the two variables to differ. The estimating procedure involves a search technique for setting a common scale factor for both lag structures, taking into account serial correlation in the disturbance terms. Additional zero end constraints are imposed. Third and second degree polynomials are used for the relative price and cost of capital terms, respectively, and a second degree polynomial is used for the credit availability term.

Multifamily units. Equation (III.4) is estimated using the relative weights for the price ratio and cost of capital terms obtained from the HSI relation, but they are shifted back one quarter.

Cost of capital, one and two-family housing units

$$(III.1) \quad RH1 = -1.14 + (1 - RTPF)(.7 RM + .3 RL + 80. RTRE)$$

Cost of capital, multi-family housing units

$$(III.2) \quad RH3 = -2.44 + .95 RM + .05 RL + 80. RTRE$$

Value of housing starts, one- and two- family units (1957-IV to 1968-IV)

$$(III.3) \quad \log [HS1/(M \cdot PHCA)] - .0022 T531 = 1.428 + \sum_0^4 w_i CR_{-i} \\ (4.0) \\ + 1.9 \left[\sum_0^7 w_i' \log (PC/PHCA)_{-i} - \sum_0^3 w_i'' \log RH1_{-i} \right] \\ + 2.63 \left[\log [(\overline{CSNH+CN})/N]_{-1:2} - \log (KH1/M)_{-2} \right] + .5 \hat{u}_{-1} \\ (4.1)$$

<u>i</u>	<u>w</u>	<u>w'</u>	<u>w''</u>
0	-.034	.000	.160
1	-.025	.000	.300
2	-.016	.050	.320
3	-.009	.122	.220
4	-.004	.192	
5		.237	
6		.235	
7		.164	
Σ	-.089	1.000	1.000

$$\text{where } CR = \begin{cases} (1.0 - (RL-RS))^2, & (RL-RS) \leq 1.0 \\ 0.0, & \text{otherwise} \end{cases}$$

$$\bar{R}^2 = .562, \overline{SEE} = .0241, SE.N(HS1) = .22, DW = 2.14$$

Value of housing starts, multi-family units (1957-IV to 1968-IV)

$$(III.4) \quad \log [HS3/(N3 \cdot PHCA)] - .0022 \text{ T531} = \underset{(1.1)}{-.5434} - \underset{(7.0)}{2.0971} [1 / (KH3_{-1} - 60.)]$$

$$+ \underset{(5.8)}{1.075} \left[\sum_0^8 w_i \log (PH/PHCA)_{-i} - \sum_0^4 w'_i \log RH3_{-i} \right]$$

$$+ \sum_0^5 w''_i CR_{-i} + .6 \hat{u}_{-1}$$

<u>i</u>	<u>w</u>	<u>w'</u>	<u>w''</u>
0	.000	.000	-.080
1	.000	.160	-.069
2	.000	.300	-.055
3	.050	.320	-.039
4	.122	.220	-.020
5	.192		
6	.237		
7	.235		
8	.164		
Σ	1.000	1.000	-.260

$$\bar{R}^2 = .650, \overline{SEE} = .0425, SE.N(HS3) = .10, DW = 1.86$$

Investment, residential structures (based on housing starts)

$$(III.5) \quad IH - IHR = 1.221 + \underset{(25.5)}{3.942} \text{ 1/PIH} \left[\sum_0^2 w_i (HS1 + HS3)_{-i} \right]$$

<u>i</u>	<u>w</u>
0	.41
1	.49
2	.10
Σ	1.00

$$\bar{R}^2 = .937, \overline{SEE} = .49, DW = 1.20$$

$$(III.6) \quad IH/N = -.0772 + .195 \overline{PH/PIH}_{-2:4} + .0124 \overline{RL-RS}_{-2:4} + .84 \hat{u}_{-1}$$

(1.2) (2.9) (5.2)

$$\bar{R}^2 = .913, \overline{SEE} = .0038, SE.N(IH) = .68, DW = 1.07$$

Stock of one- and two-family housing units

$$(III.7) \quad KH1 = .993 KH1_{-1} + (HS1/PIH)_{-1} + .213 IHR$$

Stock of multi-family housing units

$$(III.8) \quad KH3 = .995 KH3_{-1} + .667 (HS3/PIH)_{-2} + .333 (HS3/PIH)_{-3} \\ + .038 IHR$$

III. Definitions of Symbols

CN	Personal consumption expenditures, nondurable goods, billions of 1958 dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
HS1	Value of one-and two-family housing starts, billions of dollars at quarterly rates
HS3	Value of multifamily housing starts, billions of dollars at quarterly rates
IH	Investment in residential structures, billions of 1958 dollars
*IHR	Investment in residential structures other than new units (additions, alterations, etc.), billions of 1958 dollars
KH1	Stock of one-and two-family housing units at end of quarter, billions of 1958 dollars
KH3	Stock of multifamily housing units at end of quarter, billions of 1958 dollars
*N	Total population, millions
*N1	Population aged 25-64, millions
*N3	Population aged 20-24 and over 65, millions
PC	Implicit price deflator, personal consumption expenditures, 1958 = 1.000
PH	Implicit price deflator, personal consumption expenditures, housing services, 1958 = 1.000
PHCA	Index of residential construction cost (adjusted), 1957-59 = 1.000
PIH	Implicit price deflator, investment in residential structures, 1958 = 1.000
RH1	Cost of capital, one-and two-family housing units, percent
RH3	Cost of capital, multifamily housing units, percent
RL	Corporate bond yield (Moody's) percent
RM	Secondary market yield on FHA-insured mortgages, percent

RS Average yield on 4-6 month commercial paper, percent
*RTPF Effective Federal personal income tax rate, decimal
*RTRE Average rate on property taxes, decimal
*T531 Time in quarters, 1953-I = 1.0

*exogenous

Change in business inventories

Changes in the rate of inventory accumulation have often been a major component of changes in overall economic activity. In the post-World War II period inventory change generally dominated cyclical movements. Deriving satisfactory equations for inventory investment has been hampered, however, by its residual and therefore frequently erratic character and probably by relatively large errors of measurement. Because of the high degree of endogeneity in the explanatory variables, inventory equations are subject to substantial additional sources of error in the context of a complete model.

While there is theoretical justification for disaggregating inventory investment by stage of fabrication and by sectors producing to stock and to order, there is as yet no evidence that better predictions would result. (see Courchene [7]). Moreover, certain practical difficulties are involved in such disaggregation. We do, however, disaggregate inventory change into auto and nonauto components [equations (IV.1) and (IV.2)]. This split seems justified because of sufficient difference in behavioral structure and because post-sample estimates indicate smaller errors for total inventory change than are obtained from a single equation.

Both equations incorporate a stock adjustment process. The auto inventory equation omits certain variables appearing in the nonauto inventory equation. The latter equation is similar in form to the aggregate equation used by Duesenberry, Eckstein, and Fromm [10, pp. 795-800].

Consider a simple stock-sales relationship:

$$(IV.2.1) \quad II = a_1 S - a_2 \Delta S - a_3 KI_{-1},$$

where II is change in inventories, KI is end-of-quarter inventory stock and S is final sales. This formulation is most appropriate to finished goods inventories in a production-to-stock sector and can be rationalized in terms of a stock adjustment model with respect to expected sales.

The underlying partial adjustment equation is:

$$(IV.2.2) \quad II = \Delta KI = \lambda_1 (\alpha S^e - KI_{-1}) + \lambda_2 (S^e - S); \quad 0 < \lambda_1 < 1; \quad 0 < \lambda_2 < 1.$$

S^e is expected sales, αS^e represents "desired" inventory stock, λ_1 is the partial adjustment coefficient, and λ_2 indicates the flexibility of production response to errors in sales expectations. The first right-hand term in the equation represents intended inventory investment (or disinvestment) and the second, unintended inventory change due to differences between expected and actual sales. Implicit sales expectations can be derived by a generalization of Muth's [47] "rational expectations" hypothesis,

namely that expectations (S^e) are a weighted average of static ($S^e = S_{-1}$) and perfect ($S^e = S$) expectations:

$$(IV.2.3) \quad S^e = \rho S_{-1} + (1 - \rho) S; \quad 0 < \rho < 1.$$

This assumption was adopted by Lovell [42] in a study of inventory investment in which no explicit expectations data were used. It was tested by Hirsch and Lovell [28, Ch. 5], using expectations data from BEA's Manufacturers' Inventory and Sales Expectations Survey. The latter study found that this formulation was superior to assuming an explicit structure by which expectations are generated, such as Ferber's [17] extrapolative expectations assumption or Nerlove's [48] adaptive expectations model.

Substituting (IV.2.3) into (IV.2.2) yields:

$$(IV.2.4) \quad \begin{aligned} II &= \lambda_1 [\alpha \rho S_{-1} + \alpha (1 - \rho) S - KI_{-1}] - \lambda_2 \rho \Delta S \\ &= \lambda_1 (\alpha S - KI_{-1}) - (\lambda_1 \alpha + \lambda_2) \rho \Delta S. \end{aligned}$$

Thus, in terms of (IV.2.1):

$$a_1 = \lambda_1 \alpha; \quad a_2 = (\lambda_1 \alpha + \lambda_2) \rho; \quad a_3 = \lambda_1.$$

We can identify (statistically) λ_1 and α from a_1 and a_3 , but we cannot determine λ_2 and ρ without explicit expectations data, which are not available for the total private sector.

The nonauto inventory equation (IV.2) contains, in addition to the variables contained in (IV.2.1), the lagged change in inventories, the lagged change in unfilled orders, and a dummy variable to represent the effects of a steel strike (actual or anticipated).

The lagged change in inventories may be playing two roles: (1) It serves as a crude correction for the fact that only final and not intermediate sales are represented; and (2) it may absorb part of the impact of production smoothing behavior. The first role can be shown to follow from a multisector model, in which intermediate sales of some sectors feed partly into inventory change of others. With respect to the second role, Hirsch and Lovell [28, Ch. 6] provided evidence that production's smoothing occurs in actual behavior, if not in planning production. This would be reflected in a lagged output term; but since a lagged sales term already occurs in the equation, lagged inventory change is required to make it complete. 1/

1/ Note that $a_1 S - a_2 \Delta S = (a_1 - a_2) S + a_2 S_{-1}$.

The lagged change in unfilled orders plays a dual role. Usually it is a proxy for new orders, which dominate short-run changes in unfilled orders--shipments being comparatively smooth. In that capacity, it relates to the desire to hold inventories in the production-to-order sector. New orders are also relevant to material inventories in the production-to-stock sector, insofar as such orders are thought of as orders placed rather than received. In times of short supply this variable can also represent stockpiling as a hedge against anticipated shortages.

Orders and shipments of manufacturers' durable goods

A group of three recursive equations [(IV.8) to (IV.10)] explains unfilled orders of manufacturers' durable goods. This variable (in change form) appears in the nonauto inventory investment equation (with a lag) and in two of the component price deflator equations.

The change in unfilled orders from the end of quarter $t-1$ to the end of quarter t is, in principle, exactly equal to the excess of new orders over shipments during quarter t . Because each relevant series is adjusted by independent seasonal factors and deflated by the wholesale price index of durable manufactures, the identity does not hold exactly; that is, equation (IV.10), which looks like an identity, has a stochastic element. 2/

New orders for manufacturers' durables consist of orders for consumer, producer, and defense goods. While the present model does not disaggregate orders by these market categories, variables are included in the regression to represent each [equation (IV.8)]. Thus, we have as explanatory variables current purchases of consumer durables, lagged changes in real private nonresidential GNP--an accelerator-type variable to account for producers' durable equipment orders--and lagged prime military contract awards. The equation also includes lagged inventory stock, which when relatively large, would tend to depress the flow of orders in all categories, and a dummy variable to allow for unusual declines in orders after the Korean conflict.

Shipments, of course, are responses to current and past new orders. The equations for shipments (IV.9) is estimated with a variable-weight distributed lag with respect to new orders, the variable element being the ratio of unfilled orders to shipments. When recent ratios of unfilled orders to shipments are high, shipments tend to be relatively delayed. This is reflected in the progression of the second set of weights from negative to positive.

2/ A least squares fit of the relation:

$$\Delta \text{UMD} = \alpha_0 + \alpha_1 (\text{OMD} - \text{SMD})$$

was tried but α_0 and α_1 do not differ significantly from zero and unity respectively.

The ratio of unfilled orders to shipments varies partly because of changes in output mix. A more important reason, however, is that production schedule changes are costly so that firms respond gradually to changes in the flow of new orders. In periods of high capacity utilization there may also be backlog buildups because of supply bottlenecks. A dummy variable is also included to reflect the marked distortion of shipments about the time of the 1959 steel strike.

If all new orders resulted in shipments (i.e., there were no cancellations) and the data were in unadjusted form (i.e., not independently seasonally adjusted and undeflated), the sum of the distributed lag weights would have to be constrained to unity. ^{3/} Since neither condition holds, the relationship is estimated with straightforward application of the Almon procedure. The constant or intercept parts of the weights do sum to near unity, and the coefficients of unfilled orders-to-shipments ratios sum to approximately zero.

^{3/} See Tinsley [60] for the estimating procedure to be used under this assumption. For a somewhat simpler approach, see Popkin [52].

Equations for Section IV

Change in business inventories, autos and parts

$$(IV.1) \quad IIA = -1.51 + .253 CA - .149 \Delta CA - 1.78 KIA_{-1} + .649 DCA1$$

(5.2) (1.4) (5.0) (1.8)

$$\overline{R}^2 = .371, \overline{SEE} = .89, DW = 1.82$$

Change in business inventories, nonauto

$$(IV.2) \quad IINA = 3.4 + .231 (X-II-CSNH-CA) - .437 \Delta (X-II-CSNH-CA)$$

(5.3) (4.8)

$$+ .340 IINA_{-1} - .531 KINA_{-1} + .558 \Delta UMD_{-1} + 1.81 DII$$

(4.2) (4.8) (5.1) (2.7)

$$\overline{R}^2 = .828, \overline{SEE} = 1.81, DW = 1.76$$

Total change in business inventories

$$(IV.3) \quad II = IIA + IINA$$

Change in business inventories, current dollars

$$(IV.4) \quad IIDOL = PWMD \bullet II$$

$\overline{SEE} = .21$

Stock of inventories, autos and parts

$$(IV.5) \quad KIA = KIA_{-1} + .25 IIA$$

Stock of inventories, nonauto

$$(IV.6) \quad KINA = KINA_{-1} + .25 IINA$$

Total stock of inventories

$$(IV.7) \quad KI = KIA + KINA$$

Manufacturers' new orders for durable goods

$$(IV.8) \quad OMD = 35.4 + 1.201 (CA+CDNA) + .0334 (X_{-1} - X_{-8})$$

(11.3) (1.5)

$$- .377 KI_{-1} + .312 PCAWM_{-1} - 5.098 DUMD$$

(5.2) (4.6) (3.0)

$$\bar{R}^2 = .964, \overline{SEE} = 2.24, DW = 1.35$$

Manufacturers' shipments of durable goods

$$(IV.9) \quad SMD = .238 + \sum_0^4 w_i OMD + \sum_0^4 w'_i [(UMD/SMD)_{-1} OMD]$$

$$+ 1.921 DSMD$$

(2.9)

<u>i</u>	<u>w</u>	<u>w'</u>
0	.625	-.131
1	.307	-.066
2	.095	-.002
3	-.011	.063
4	-.010	.128
Σ	1.006	-.007

$$\bar{R}^2 = .986, \overline{SEE} = 1.26, DW = 1.17$$

Manufacturers' unfilled orders for durable goods

$$(IV.10) \quad UMD = UMD_{-1} + OMD - SMD$$

$\overline{SEE} = .55$

IV. Definitions of Symbols

CA	Personal consumption expenditures, automobiles and parts, billions of 1958 dollars
CDNA	Personal consumption expenditures, nonauto durable goods, billions of 1958 dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
*DCA1	Strike dummy for auto consumption: 1956-III = 1.0, 1956-IV = 1.0, 1959-IV = -1.0, 1960-I = 1.0, 1964-IV = -1.0, 1965-I = 1.0, 1966-II = -1.0, 1967-III = -0.4, 1967-IV = -0.6, 1968-I = 1.0, 1968-II = 0.7; otherwise = 0.0
*DII	Strike dummy for nonauto inventory investment: 1959-II = 1.0, 1959-III = -2.0, 1960-I = 1.0, 1965-I = 1.0, 1968-II = 0.5, 1968-III = 0.5; otherwise = 0.0
*DSMD	Dummy for manufacturing shipments: 1959-II = 1.0, 1959-III = -1.0, 1960-I = 1.0; otherwise = 0.0
*DUMD	Dummy for Korean conflict effects on unfilled orders: 1953-III and 1953-IV = 1.0; otherwise = 0.0
II	Change in business inventories, billions of 1958 dollars
IIA	Change in business inventories, autos and parts, billions of 1958 dollars
IIDOL	Change in business inventories, billions of dollars
IINA	Change in business inventories, nonauto, billions of 1958 dollars
KI	Stock of inventories at end of quarter, billions of 1958 dollars
KIA	Stock of inventories at end of quarter, autos and parts, billions of 1958 dollars
KINA	Stock of inventories at end of quarter, nonauto, billions of 1958 dollars
OMD	Manufacturers' new orders for durable goods, billions of 1958 dollars
*PCAWM	Prime military contract awards, billions of 1958 dollars

PWMD	Wholesale price index, manufacturers' durable goods, 1957-59 = 1.000
SMD	Manufacturers' shipments* of durable goods, billions of 1958 dollars
UMD	Manufacturers' unfilled orders for durable goods at end of quarter, billions of 1958 dollars
X	Private nonresidential output, billions of 1958 dollars

*exogenous

V. IMPORTS AND EXPORTS

Equation (V.1) relates merchandise imports to the average of current and lagged private output and to the lagged relative price of imports. Since merchandise imports are comprised of finished goods, on one hand, and crude materials and semi-manufactures, on the other, output serves a dual role: (1) As a direct requirements variable and (2) as a real income proxy. The coefficient of output is variable, depending on capacity utilization;^{1/} that is, the marginal propensity to import rises with capacity utilization. The equation is estimated for real imports net of "special" factors. These special factors are quantitative estimates of the direct impact of strikes (including pre- and post-strike makeups and stockpiling or import substitution for domestic strikes), imports of U.S. cars manufactured in Canada, and miscellaneous factors.

Equations (V.2a) and (V.2b) explain other (nonmerchandise, nonmilitary) imports. Such imports consist of services--mainly tourism and shipping costs--and income earned by foreigners in the United States. The two equations represent regressions estimated for two subperiods of the total sample period, with the dividing point between them set at the end of 1958. This split was deemed necessary because of an apparent structural change in the relationship. Both equations use disposable income as an explanatory variable to represent primarily the consumer component of services. Lagged services imports are included in equation (V.2b), but for the earlier period this variable is not significant. Thus the term is omitted.

Military imports and all exports are treated exogenously.

^{1/} We use the "industrial" (manufacturing, mining, and utilities) component of the Wharton Index (see Klein and Summers [37]).

Merchandise imports

$$(V.1) \quad \Delta (IMT-IMTS) = \underset{(6.5)}{.0149} \Delta \left[CUW \sum_0^1 X_{-i} \right] - \underset{(2.4)}{13.7} \Delta (PIM/P)_{-1}$$

$$\bar{R}^2 = .991, \overline{SEE} = .467, DW = 2.01$$

Other nonmilitary imports

1953-II to 1958-IV

$$(V.2a) \quad IMS = -3.384 + \underset{(30.3)}{.0249} DPI/PIM$$

$$\bar{R}^2 = .977, \overline{SEE} = .090, DW = 1.86$$

1959-I to 1968-IV

$$(V.2b) \quad IMS = -1.116 + \underset{(2.3)}{.00824} DPI/PIM + \underset{(4.3)}{.690} \overline{IMS}_{-1:4}$$

$$\bar{R}^2 = .990, \overline{SEE} = .168, DW = 1.57$$

V. Definitions of Symbols

CUW	Utilization rate of industrial capacity for manufacturing, mining and utilities, Wharton index, decimal
DPI	Disposable personal income, billions of dollars
*EXP	Exports, billions of dollars
*IMG	Military imports of goods and services, billions of dollars
IMS	Imports of nonmilitary services, billions of 1958 dollars
INT	Merchandise imports, billions of 1958 dollars
*IMTS	Merchandise imports, special factors, billions of 1958 dollars
P	Implicit price deflator, private nonresidential output, 1958 = 1.000
*PEX	Implicit price deflator, exports, 1958 = 1.000
*PIM	Implicit price deflator, imports, 1958 = 1.000
X	Private nonresidential output, billions of 1958 dollars

*exogenous

VI. GOVERNMENT PURCHASES OF GOODS AND SERVICES

Current-dollar government purchases of goods and services are exogenous. Purchases in constant dollars, however, are endogenous [equation (VI.1)], since the implicit price deflator for purchases (other than purchases of factor services, i.e., employee compensation) is endogenously determined. Thus, if prices of goods purchased by governments rise more than expected, real purchases will be less than expected. This makes sense if one views budgets and appropriations as determining the current-dollar value, rather than the physical volume of purchases.

Government purchases enter the identities for total GNP (Section VII) and for the fiscal balances of Federal and of State and local governments (Section XI).

Equation for Section VI

Government purchases of goods and services, 1958 dollars

$$(VI.1) \quad G58 = (GFD + GFND + GSL - WG)/PGG + WG/PWG$$

VI. Definitions of Symbols

G58	Government purchases of goods and services, billions of 1958 dollars
*GFD	Government purchases of goods and services, Federal defense, billions of dollars
*GFND	Government purchases of goods and services, Federal nondefense, billions of dollars
*GSL	Government purchases of goods and services, State and local, billions of dollars
PGG	Implicit price deflator, government purchases of goods, 1958 = 1.000
*PWG	Implicit price deflator, compensation of general government employees, 1958 = 1.000
*W/G	Compensation of general government employees, billions of dollars

*exogenous

VII. OUTPUT AND CAPACITY UTILIZATION

Equations (VII.1) through (VII.3) are identities for current and constant dollar values of GNP and gross private nonresidential output (i.e., private GNP excluding housing services). The latter--denoted by X--is used frequently in the model as the basic output measure.

The two remaining equations--one for potential private nonresidential output (VII.4) and another for the Wharton index of capacity utilization (VII.5)--derive from a single regression. Consider the following homogeneous Cobb-Douglas production function for potential output:

$$(VII.4.1) \quad XP = A(t) KSE_{-1}^{\alpha} (EP \times HP)^{1 - \alpha},$$

where $A(t)$ is a trend function of technical change, KSE is end-of-period net stock of plant and equipment, EP is potential private employment, and HP is "potential" or "standard" weekly hours. (EP and HP are derived in the next section.) We assume that potential capital input is adequately represented by the actual stock; EP x HP represents sustainable potential man-hours.

Multiplying both sides of equation (VII.4.1) by X/XP yields the following production function for actual output:

$$(VII.4.2) \quad X = A(t) \frac{X}{XP} KSE_{-1}^{\alpha} (EP \times HP)^{1 - \alpha}.$$

Equation (VII.4.2) can be estimated, if we substitute an extraneous measure of utilization for X/XP . Using the Wharton index for manufacturing, mining, and utilities, i.e., the "industrial" sector, we define:

$$(VII.5.1) \quad \frac{X}{XP} = CUW^{\beta_1} \left[\frac{CSNH/X}{(CSNH/X)'} \right]^{\beta_2},$$

where $\frac{CSNH/X}{(CSNH/X)'}$ is the ratio of consumer services to private nonresidential GNP divided by this ratio at peak activity.^{1/} The second term serves as a crude correction factor to allow for the fact that services constitute an important sector--one whose output is cyclically relatively stable. Services are not included in the Wharton index, but they do occur in the economy-wide measure.

^{1/} $(CSNH/X)'$ is obtained graphically by drawing lines connecting relative minimum points of CSNH/X. CSNH is more stable than X; thus CSNH/X varies inversely with the business cycle. A precise definition of $(CSNH/X)'$ is given with the estimating form of equation (VII.5).

Substituting equation (VII.5.1) into equation (VII.4.2) and converting to logarithms yields the desired estimating form. However, because of strong correlation between the two right-hand variables in equation (VII.5.1), the equation is estimated with log CUW as the dependent variable. Also, because of collinearity between the time trend and $\log \left(\frac{KSE-1}{EP \times HP} \right)$ it was necessary to use an a priori estimate for α of 0.3, which corresponds roughly to the nonwage income share. The estimated form for log CUW is shown in the equation list following equation (VII.5).

The parameters in equation (VII.4.1) and the derived series for potential output (VII.4) are obtained by using the parameters in the retransposed CUW equation (making X the dependent variable again) and by imposing the following two conditions: 2/

$$CUW = 1.0$$

$$CSNH/X = (CSNH/X)' ;$$

that is, the Wharton index is set at full capacity and CSNH/X at levels corresponding to cyclical peaks. Since CUW is used as a variable elsewhere in the model, equation (VII.5) is used to derive predictions of CUW. This equation is simply a restatement of the equivalent estimating form for CUW with XP substituted for its definition.

2/ Our approach to estimating potential output is similar to that of Solow [56] and Taylor and Thurow [58]. However, they use the unemployment rate rather than a capacity utilization measure.

Equations for Section VII

Gross private nonresidential output, constant dollars

$$(VII.1) \quad X = C - CH + IH + ISE + II + EXP/PEX - (IMT + IMS + IMG/PIM) \\ + G58 - WG/PWG$$

Gross national product, constant dollars

$$(VII.2) \quad GNP58 = X + CH + WG/PWG$$

Gross national product, current dollars

$$(VII.3) \quad GNP = P \cdot X + PH \cdot CH + WG$$

Potential private nonresidential output

$$(VII.4) \quad \log XP = -.562 + .00222 T531 + .3 \log KSE_{-1} + .7 \log (EP \cdot HP)$$

Capacity utilization, Wharton index

$$(VII.5) \quad \log CUW = 1.55 \log (X/XP) - .277 \log \left[(CSNH/X) / \right. \\ \left. (CSNH/X)' \right] + .83 \hat{u}_{-1}$$

derived from the estimated form:

$$\log CUW = .8716 - .00344 T531 - .277 \log \left[(CSNH/X) / \right. \\ (5.3) \quad (1.1) \quad \left. (CSNH/X)' \right] + 1.552 \left[\log (X/(EP \cdot HP)) \right. \\ (6.3) \quad \left. - .3 \log (KSE_{-1}/(EP \cdot HP)) \right] + .83 \hat{u}_{-1}$$

$$\text{where } (CSNH/X)' = \begin{cases} .1727 + .00012 T531_{-2}, & \text{when } T531 \leq 1955-II \\ .1738 + .00017 T531_{-11}, & \text{when } T531 > 1955-II \end{cases}$$

$$\bar{R}^2 = .961, \overline{SEE} = .0053, SE.N(CUW) = .011,$$

$$DW = 1.83$$

VII. Definitions of Symbols

C	Personal consumption expenditures, billions of 1958 dollars
CH	Personal consumption expenditures, housing services, billions of 1958 dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
CUW	Utilization rate of industrial capacity for manufacturing, mining and utilities, Wharton index, decimal
EP	Potential private civilian employment, millions
*EXP	Exports, billions of dollars
G58	Government purchases of goods and services, billions of 1958 dollars
GNP	Gross national product, billions of dollars
GNP58	Gross national product, billions of 1958 dollars
HP	Average weekly hours, potential
IH	Investment in residential structures, billions of 1958 dollars
II	Change in business inventories, billions of 1958 dollars
*IMG	Military imports of goods and services, billions of dollars
IMS	Imports of nonmilitary services, billions of 1958 dollars
INT	Merchandise imports, billions of 1958 dollars
ISE	Nonresidential fixed investment, billions of 1958 dollars
KSE	Net stock of nonresidential structures and equipment at end of quarter, billions of 1958 dollars (Constant Cost I, average life = 85% of Bulletin F)
P	Implicit price deflator, private nonresidential output, 1958 = 1.000
*PEX	Implicit price deflator, exports, 1958 = 1.000

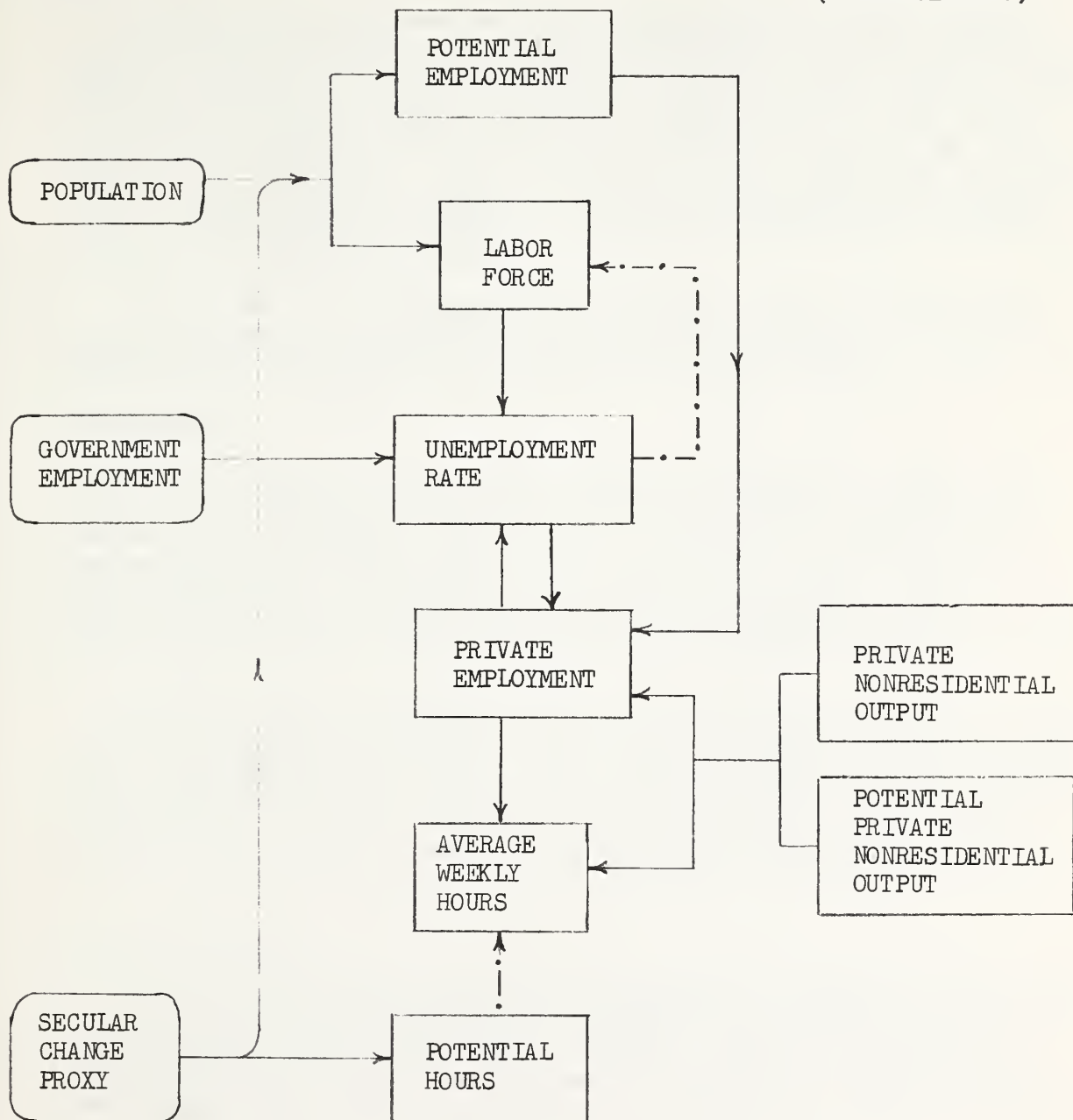
PH	Implicit price deflator, personal consumption expenditures, housing services, 1958 = 1.000
*PIM	Implicit price deflator, imports 1958 = 1.000
*PWG	Implicit price deflator, compensation of general government employees, 1958 = 1.000
*T531	Time in quarters, 1953-I = 1.0
*WG	Compensation of general government employees, billions of dollars
X	Private nonresidential output, billions of 1958 dollars
XP	Potential private nonresidential output, billions of 1958 dollars

*exogenous

SIMPLIFIED FLOW CHART FOR LABOR FORCE, EMPLOYMENT AND HOURS SECTOR

EXOGENOUS
VARIABLES

ENDOGENOUS
VARIABLES
(OTHER SECTORS)



— current

-.-.- current and lagged

VIII. LABOR FORCE, EMPLOYMENT, AND HOURS

Prediction of labor force and employment in the model serves a two-fold purpose: First, these variables yield the unemployment rate, which is of interest in its own right as a policy target. Second, both employment and unemployment feed back to other sectors of the model: specifically, employment multiplied by wage per employee, yields wage payments. In addition, the unemployment rate is an important determinant of the wage rate.

Briefly, the mechanism of this sector works as follows (see the accompanying flow chart): The size of the labor force is influenced mainly by that of the work-age population and by secular factors affecting the participation rate. Short-run changes in private employment and hours ^{1/} are basically determined by output behavior. Government employment is exogenous. The unemployment rate is determined residually from labor force and employment. The latter, representing employment opportunities, however, feeds back (through an intermediate variable) to the labor force participation rate.

The roles of the "extrapolated" variables--potential employment, potential hours, and potential output--and the usually minor impact of the unemployment rate on employment are explained below.

Labor force

Civilian labor force is split into two components: males aged 25-54 years, called the "primary" labor force, and the remainder of the adult, or "secondary" labor force. Participation rate equations are estimated for each group. The studies of Tella [59] and Mincer [44] help considerably in the formulation of these equations. The participation rate of the primary labor force [equation (VIII.1)] is both high and cyclically stable; it shows a slight negative trend.

The residual or secondary labor force participation rate shows both cyclical and secular variation. The secular movement is one of increase and is represented by a trend. Since the participation rate presumably has a saturation level, we estimate in log form the complement of the participation rate. The resulting trend is negative. This implies a secular increase in the participation rate at a diminishing rate.

^{1/} Total private weekly hours are not needed for solution of the overall model, but they are obtained, primarily to yield the wage rate and productivity in terms of man-hours. However, hours of manufacturing production workers, which are separately determined, do feed back into the system.

The other important variable in equation (VIII.2) is the unemployment rate for the primary labor force, which enters with a distributed lag. The lag weights are preset since Almon-type estimates did not yield satisfactory results. The log form implies a constant elasticity of the participation rate with respect to the unemployment rate. As a result, a given change in percentage points in the unemployment rate has a more powerful effect on the participation rate when the unemployment rate is low, than when it is high. This is justified in view of the dual role this variable plays: On the one hand, it represents employment opportunities, and thus has a negative impact on participation; on the other hand, at higher rates of unemployment the need for additional workers in a household to maintain family income becomes an opposing, though less than offsetting force. ^{2/} Use of the primary unemployment rate in the secondary labor force equation also avoids the error-in-variables bias, noted by Mincer [44], which results from the use of the own employment rate as an explanatory variable.

Finally, a dummy variable that makes crude allowance for the abnormally low participation rate after the Korean conflict is included. It is held at 1.0 during 1953 and 1954 and tapered to zero by 1955-III.

"Potential" primary and secondary labor force values are required to estimate potential employment. Since the primary labor force participation rate does not vary cyclically, observed levels of this labor force component are used. Potential secondary labor force [equation (VIII.3)] is obtained by using parameters from equation (VIII.2), but omitting the unemployment term and setting the constant term so that the resulting series of "potential" participation rates pass through the highest relative peak of observed rates during the sample period.

Potential private employment [equations (VIII.4a) and (VIII.4b)] is obtained by applying assumed "frictional" rates of unemployment to primary and potential secondary labor force and subtracting general government employment. The frictional rate for primary unemployment is set at 1.3 percent--slightly lower than the lowest observed rate of 1.5 percent. The unemployment rate for secondary workers has generally been above that of the primary labor force. However, from 1953 to about 1966 the spread between them increased, reflecting primarily secular growth in the unemployment rate of the former. Thus, unemployment become increasingly concentrated among secondary workers, suggesting a rising amount of structural unemployment, if we assume that "primary" and "secondary" workers are to some degree complementary. In order to take this phenomenon into account, the rate used to adjust potential secondary labor force to obtain potential employment is based on the initial spread of unemployment rates and the trend in the spread.

^{2/} Mincer [44, p. 93] found the additional worker phenomenon particularly prominent among nonwhite women aged 25-34 years.

Employment

Most quarterly econometric models have departed from the direct use of neoclassical production functions as a basis for determining employment or man-hours. Beginning with the empirical study of Hultgren [30], research has clearly shown that in the cyclical short run the behavior of employment and hours is only loosely tied to a production function. Indeed, the observed procyclical behavior of output per man-hour is inconsistent with a production function having continuously diminishing returns. Some writers have approached the problem by using an inverted production function, making employment or man-hours the dependent variable and allowing for distributed lag adjustment with respect to output and trend factors. Sometimes they have separated capital stock. Others, notably Wilson and Eckstein [62] and more recently Fair [16], have utilized short-run functions, divorced from neoclassical production functions.

Our procedure straddles these two approaches, though in spirit it most closely approximates that of Fair. More specifically, in our model the relationship between output on the one hand and desired employment and weekly hours on the other coincides with a neoclassical (Cobb-Douglas) production function only under "full" utilization of capital and potential man-hours. With less than full utilization, the relationship departs from the neoclassical production function surface but the production function still imposes a constraint on the relationship.

The technical assumptions underlying this approach are that: (1) The production function is always operative in terms of "effective" inputs; i.e., machine-hours and effective--as distinct from measured--man-hours; (2) effective labor and capital inputs vary in virtually fixed proportion when variation takes place via the rate of utilization. (This is consistent with a "putty-clay" production function.) A distinction between measured and effective man-hours arises from the fact that intensity of labor effort varies. 3/

Variation in labor intensity is basically cyclical in character. It tends to be lowest in recessions and highest near peaks or in periods of rapid growth. This accounts for the positive short-run relationship between output and measured man-hour productivity. In part, this phenomenon is explained simply by lags in the adjustment of employment and hours to labor requirements. However, if medium-run expectations of output are below long-run expectations, man-hours will tend to remain above the technically required level; that is, the downward adjustment of employment and hours will not be complete. This usually occurs during recessions or sustained periods of underemployment, such as from 1958 to 1965. It happens because of the quasi-fixed nature of much employment, costs of rehiring and training, and the tendency for the work week not to stray far from its customary length.

3/ Fair's [16, pp. 41-50] model is also heavily based on this distinction, which he imputes to the difference between "hours paid for" and "hours worked."

Thus, effective utilization of measured man-hours varies with the cyclical state of the economy, even after short-run adjustments are allowed for; and the extent to which the desired relationship between output and nominal man-hours departs from the relationship, defined by the production function, varies accordingly. The variability of (nominal) hours worked does serve as a buffer, tending to obviate the need for full adjustment of employment; but hours do not respond sufficiently to eradicate underutilization of man-hours.

Consider the following model for desired employment (E^*):

$$(VIII.5.1) \quad E^* = EP (X^*/XP) \lambda_e,$$

where EP and XP are, respectively, potential employment and output and X^* is expected output. Actual output (X) is assumed to serve as a proxy for expected output. ^{4/} Potential man-hours and potential output are related by the production function (VII.4), discussed in the previous section.

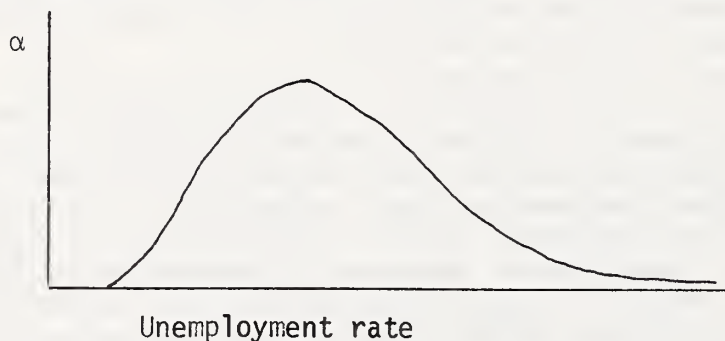
The equation for desired employment is coupled with the following partial adjustment process:

$$(VIII.5.2) \quad (E/E_{-1}) = (E^*/E_{-1})^\alpha,$$

where E is actual employment.

The speed of adjustment α is made a nonlinear function of the primary unemployment rate, approximating the general shape shown in the figure below.

We expect the speed of response to be relatively slow at both high and low rates of unemployment. Slow adjustment occurs with high unemployment



^{4/} We tried a form similar to the rational expectations proxy underlying the sales terms in the inventory investment equations, namely:

$$\text{Log } X^* = \eta \log X + (1 - \eta) \log X_{-1}$$

but this did not give reasonable parameter estimates.

rates (i.e., near cyclical troughs) for two reasons: one associated with decreases and the other with increases in output. As output declines, firms become increasingly reluctant to lay off more workers as they approach their pure overhead work force. When output rises, firms are hesitant to rehire, until they are confident of sustained recovery. At low unemployment rates (cyclical peaks) and with output increases, tight labor markets force labor input adjustments to be in hours worked rather than in employment. When output declines, overtime hours are first reduced, and labor hoarding may take place. The speed of adjustment must be highest at some intermediate rate of unemployment.

In the actual estimation of the employment function [equation (VIII.5)] is made a linear function of the primary unemployment rate:

$$(VIII.5.3) \quad \hat{\alpha} = \alpha_1 + \alpha_2 \text{ URP}.$$

Since the estimated value of α_2 is negative, it is apparent that most observations of the unemployment rate are at levels to the right of the peak in the figure above. Combining equations (VIII.5.1), (VIII.5.2), and (VIII.5.3) and translating into logarithms gives the estimating form of the equation.

For purposes of application of this equation, α is made nonlinear by imposing the following conditions:

$$(VIII.5.4) \quad \begin{aligned} \alpha &= 0 \text{ if the primary unemployment rate (URP)} \leq .01; \\ \alpha &= (\alpha_1 + \alpha_2 \text{ URP}) [1 - e^{\alpha_3 + \alpha_4 \text{ URP}}] \text{ if } .01 < \text{URP} < .06; \\ \alpha &= \text{Constant if } \text{URP} \geq .06; \end{aligned}$$

where α_3 and α_4 are determined so that: (1) $\alpha = 0$ for $\text{URP} = .01$ and (2) α is a maximum for $\text{URP} = .025$. The final function for α is then asymptotic to the estimated linear function (VIII.5.3). The complete employment relationship is shown as equation (VIII.5).

Primary unemployment rate

Equation (VIII.8) is an empirical regression relating the primary unemployment rate to the overall unemployment rate. The quadratic relationship implies that at low overall unemployment rates (in the 3 to 4 percent range) a decrease in unemployment results in a reduction in the primary rate about half as large as in the overall rate. At higher unemployment rates changes become about equal. In addition to the overall unemployment rate, the equation includes the ratio of primary to total labor force. This rate has been falling secularly, thus causing a gradual shift in the basic relationship between the overall and the primary unemployment rates. Two boundary restrictions are imposed on this function: (1) The primary unemployment rate may not fall below its frictional rate of 1.3 percent; (2) as an upper limit, the primary rate may not exceed 85 percent of the overall rate. The latter condition would be violated by the unrestricted equation only at very high unemployment rates.

Average weekly hours

A concept of potential hours is required here, analogous to that of potential employment. However, in the case of hours we opt for a concept of a "standard" work week, rather than some maximum level. In our society the notion of a "customary" work week is ingrained, and a level above this is not sustainable indefinitely, except under emergency conditions, such as World War II. However, in the short run, actual hours can be higher than standard ("potential") hours.

Potential hours (equation VIII.9), which is multiplied by potential employment to obtain potential man-hours, is derived from a regression of average private hours on the Wharton index of capacity utilization and a "kinked" time trend. A second trend is introduced in 1958-I and has a positive coefficient, partly offsetting the full-period negative trend. The smaller trend in the recent period reflects the end of the earlier sharp postwar decline in hours (centered outside of manufacturing) in the standard work week. Potential hours are obtained by omitting the capacity utilization term and setting the constant term so that computed potential hours equal the average work week for 1966-68--a period of relatively high economic activity.

The equation for average hours [equation (VIII.10)] is similar to that for employment, except that explicit allowance is made in the hours equation to compensate partially for the degree to which employment is not adjusted to its desired level, and β_1 , unlike α in the employment function, is assumed to be fixed. The partial adjustment model is:

$$(VIII.10.1) \quad H/H_{-1} = (H^*/H_{-1})^{\beta_1} (E^*/E)^{\beta_2},$$

where H^* represents desired hours. The expression for desired hours is analogous to that for desired employment, namely:

$$(VIII.10.2) \quad H^* = HP (X/XP)^{\lambda_h},$$

where HP is potential (standard) hours.

It is assumed that when economic activity is below potential levels, firms adjust their man-hour inputs, in part, by reducing hours below the standard work week: λ_h then represents the degree to which entrepreneurs allow hours to compensate in the medium run for the lack of cyclical flexibility that exists in employment; β_1 is the partial adjustment coefficient. The second term in equation (VIII.10.2) allows for additional compensatory adjustment of hours for disequilibrium in employment. When actual hours rise above standard hours, it is presumably because employment is below desired levels. This situation results in disequilibrium. The expectation that both β_1 and β_2 lie in the 0-to-1 range is met.

In addition to the equation for overall hours, there is one for average hours of manufacturing production workers [equation (VIII.11)]. This variable occurs in the auto purchases and wage rate equations. Manufacturing hours are related to the Wharton capacity utilization index and to a two-quarter relative change in private nonresidential output. These variables correspond to the variables in the aggregate hours equation. The Wharton index is, of course, analogous to X/XP . Since the deviation of actual from desired employment varies with the short-run rate of change of output, the latter variable serves a proxy role. Finally, lagged hours are included, indicating a distributed lag adjustment process.

Equations for Section VIII

Primary civilian labor force

$$(VIII.1) \quad \log (LFP/NP) = \underset{(69.2)}{-.0193} - \underset{(5.8)}{.0000432} T531$$

$$\bar{R}^2=.348, \overline{SEE}=.00107, SE.N(LFP)=.072, DW=1.01$$

Secondary civilian labor force

$$(VIII.2) \quad \log (1 - LFS/NS) = \underset{(31.3)}{-.3111} + \underset{(1.8)}{.0135} \sum_0^4 w_i \log URP_{-i} \\ - \underset{(6.3)}{.000498} T531 + \underset{(5.9)}{.0215} DLFS + .67 \hat{u}_{-1}$$

<u>i</u>	<u>w</u>
0	.20
1	.35
2	.25
3	.15
4	.05
Σ	1.00

$$\bar{R}^2=.964, \overline{SEE}=.0028, SE.N(LFS)=.30 \\ DW=1.80$$

Potential secondary civilian labor force

$$(VIII.3) \quad LFSP = NS \left[\begin{array}{l} -.341-.000498 T531 + .0215 DLFS \\ 1. - 10. \end{array} \right]$$

Potential private civilian employment

1953-II to 1965-IV

$$(VIII.4a) \quad EP = .987 LFP + (.972 - .000269 T531) LFSP - EG$$

$$(VIII.4b) \quad EP = .987 \text{ LFP} + .958 \text{ LFSP} - EG$$

Private civilian employment

$$(VIII.5) \quad \log (E/E_{-1}) = \beta \left[\log (EP/E_{-1}) + \frac{.454}{(18.0)} \log (X/XP) \right] + .42 \hat{u}_{-1}$$

$$\text{where } \beta = \begin{cases} .380, & \text{URP} \geq .06 \\ .0, & \text{URP} \leq .01 \\ (.584 - 3.396 \text{ URP}) \left[\frac{-239 \cdot (\text{URP} - .01)}{1 - e} \right], & .01 < \text{URP} < .06 \end{cases}$$

$$\bar{R}^2 = .591, \quad \overline{SEE} = .0018, \quad SE.N(E) = .29, \quad DW = 1.85$$

Civilian wage and salary employment

$$(VIII.6) \quad EW = E - EE + EG$$

Unemployment rate, total civilian labor force

$$(VIII.7) \quad UR = (LFP + LFS - E)/(LFP + LFS)$$

Unemployment rate, primary civilian labor force

$$(VIII.8) \quad URP = \underset{(1.4)}{-.0627} + \underset{(1.4)}{.224} UR + \underset{(4.3)}{7.029} (UR)^2 + \underset{(15.0)}{.155} LFP/(LFP+LFS)$$

$$\text{where } URP = \begin{cases} .85 \text{ UR}, & \text{URP} \geq .85 \text{ UR} \\ .012, & \text{URP} < .012 \end{cases}$$

$$\bar{R}^2 = .977, \quad \overline{SEE} = .0018, \quad DW = .79$$

Average potential hours, private sector

$$(VIII.9) \quad \log HP = 1.628 - .000583 T531 + .000302 T581$$

derived from the estimated form:

$$\log H = 1.6309 + .0788 \log CUW - .000583 T531 + .000302 T581$$

(1753.) (6.8) (9.0) (3.6)

$$\bar{R}^2 = .918, \overline{SEE} = .00187, DW = 1.09$$

Average hours worked, private sector

$$(VIII.10) \quad \log (H/H_{-1}) = .4394 \left[\log (HP/H_{-1}) + .0843 \log (X/XP) \right]$$

(4.7) (5.5)

$$+ .0957 \log (E'/E)$$

(1.9)

$$\text{where } \log E' = \log EP + .454 \log (X/XP)$$

$$\bar{R}^2 = .272, \overline{SEE} = .00172, SE.N(H) = .16, DW = 2.05$$

Average hours worked, manufacturing

$$(VIII.11) \quad \log HM = .6015 + .0416 \log CUW + .243 \log (X/X_{-2})$$

(4.7) (2.0) (8.6)

$$+ .626 \log HM_{-1}$$

(7.9)

$$\bar{R}^2 = .906, \overline{SEE} = .0021, SE.N(HM) = .19, DW = 1.96$$

VIII. Definition of Symbols

CUW	Utilization rate of industrial capacity for manufacturing, mining and utilities, Wharton index, decimal
*DLFS	Dummy for secondary labor force transition after the Korean conflict: 1953-I to 1955-I = 1.0, 1955-II = 0.7, 1955-III = 0.3, otherwise = 0.0
E	Private civilian employment, millions
*EE	Self-employed, millions
*EG	General civilian government employment, millions
EP	Potential private civilian employment, millions
EW	Civilian wage and salary employment, millions
H	Average weekly hours, private employees
HM	Average weekly hours for production workers in manufacturing establishments
HP	Average weekly hours, potential
LFP	Primary civilian labor force (males aged 25-54), millions
LFS	Secondary civilian labor force (total minus primary), millions
LFSP	Potential secondary labor force, millions
*NP	Primary civilian resident population (males aged 25-54), millions
*NS	Secondary civilian resident population (persons aged 16-64, except primary), millions
*T53I	Time in quarters, 1953-I = 1.0
*T58I	Time in quarters, 1958-I = 1.0, 1953-I to 1958-IV = 0.0
UR	Unemployment rate for civilian labor force, decimal
URP	Unemployment rate for primary labor force, decimal
X	Private nonresidential output, billions of 1958 dollars
XP	Potential private nonresidential output, billions of 1958 dollars

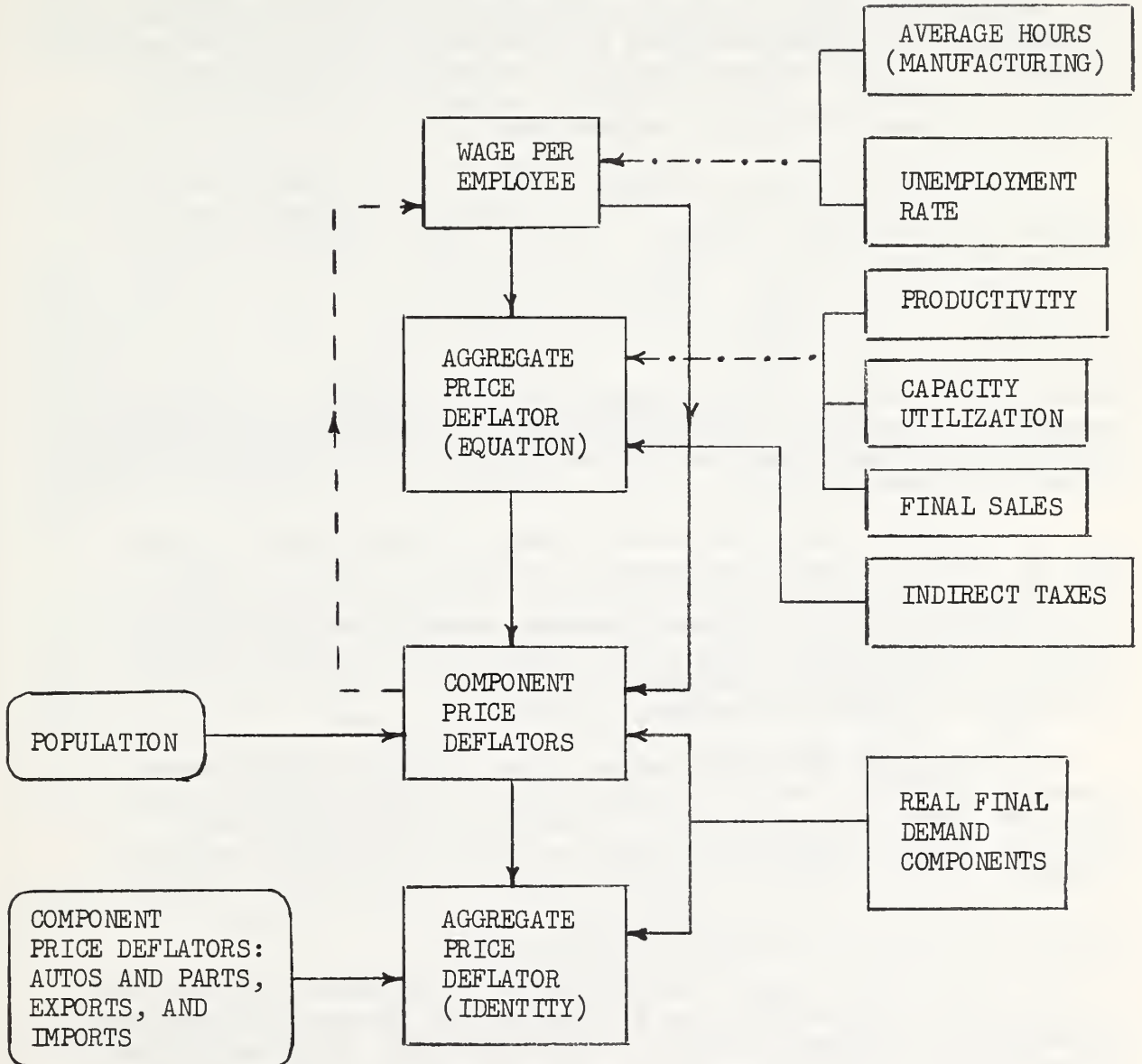
*exogenous

SIMPLIFIED FLOW CHART FOR

PRICE-WAGE SECTOR

EXOGENOUS
VARIABLES

ENDOGENOUS
VARIABLES
(OTHER SECTORS)



— current

-.-.- current and lagged

- - - lagged

IX. PRICES AND WAGE RATE

The model determines implicit price deflators and the private sector wage rate as integral parts of the simultaneous solution of the whole system. The essential mechanics of price determination are shown on the simplified flow chart for this sector. The wage rate equation is basically a Phillips curve formulation with the unemployment rate the key explanatory variable. The wage rate--along with productivity, indirect taxes, and demand factors--feeds directly into a behavior equation for an overall implicit price deflator (P), namely, that for private nonresidential GNP. This estimate for P and the wage rate are the main determinants of component deflators. There are additional explanatory variables in component deflator equations, which are specific to these final demand categories. Certain component deflators, as shown in the accompanying chart, are exogenous. The total personal consumption expenditures deflator feeds back with lags to the wage rate.

The component deflators, together with real final demands, however, imply an overall deflator which is not, in general, the same as the value derived from the behavior equation. That is, given component deflators, P_i , and corresponding final demands, X_i , we have:

$$(IX.2.1) \quad P = \frac{P_i X_i}{X_i}, i = 1, \dots, n,$$

where n is the number of final demand items in X , according to the disaggregation in the model. Overdetermination is circumvented by replacing the equation-derived value for P by the weighted sum of component deflators given by the identity (IX.2.1).

As a result of tests reported by Hirsch [27], we prefer this procedure to arbitrarily adjusting component deflators so that the weighted sum agrees with the single-equation value. It should be noted, however, that although under the preferred procedure a preliminary estimate of the overall deflator is replaced, the original overall estimate is still important in establishing the general price level since it is heavily relied upon to obtain the component deflators.

We also prefer the present method to the alternative of estimating component deflators directly without an overall equation estimate of P , since the final demand categories are typically not meaningful market groupings for which appropriate supply and demand determinants are well defined.

Implicit deflator for private nonresidential GNP

As in many other models, the formulation of the overall price level in equation (IX.1) is basically that of a markup over average unit labor cost. The dependent variable is price at gross factor cost. It is used on the assumption that indirect taxes are fully and immediately passed on to the final purchaser. The degree of markup over current unit labor cost is variable because of: (1) Modifications to the actual unit labor cost measure, (2) distributed lag adjustments, (3) the direct role of aggregate demand, and (4) a secular trend adjustment in the markup. Each aspect is discussed below.

Unit labor cost (ULC) is defined as private employee compensation per dollar of real private nonresidential GNP. Since compensation, though not our wage rate measure, includes employer contributions for social insurance, the employer portion of changes in social security tax rates or coverage is passed forward to the price level. Following the work of Eckstein and Fromm [12], we use both actual unit labor cost (ULC) and a modified measure of unit labor cost (ULC') that abstracts from short-run changes in productivity. However, unlike Eckstein and Fromm, we do not use a trend measure of productivity, but rather a "medium-run" equilibrium measure, which is derived from the steady-state, output-employment relationship in the model (see Section VIII). This measure abstracts from short-run disequilibria in the adjustment of employment to output, yet retains some degree of cyclical variability.

Neglecting for the moment factors other than unit labor cost, the steady-state equation for the price level is:

$$(IX.1.1) \quad P^* = A(t)(ULC^*)^\alpha(ULC'^*)^{1-\alpha},$$

where the asterisks denote steady-state values. "Effective" unit labor cost is thus a weighted (geometric) mean of the actual and modified variants of unit cost. The elasticity of price with respect to effective unit labor cost is constrained to unity. This is consistent both with the empirical findings of Gordon [24] and with a constant long-run markup over average cost, given a Cobb-Douglas production function. ^{1/} The secular drift in the markup ratio, consistent with a small secular rise in labor's share, is represented by an exponential trend. The trend is slight, but significantly negative and may reflect some combination of changing market structure and a changing product mix.

The overall price equation incorporates a distributed lag adjustment of prices to changes in effective unit labor cost. This is appropriate on two grounds: (1) Many firms, particularly those operating under relatively competitive conditions, will not raise prices immediately in response to a rise in labor costs, while in oligopolistic markets there is also downward price rigidity; and (2) since the price deflator represents prices of final goods, it also embodies lags in transmission of price changes through stages of production.

In addition to unit labor cost, there are two demand-related terms in the equation. Both serve to vary the markup ratio of price to unit labor cost. Thus equation (IX.1.1) is modified to:

$$(IX.1.2) \quad P^* = A'(t)(D_1^*)^\beta(D_2^*)^\delta(ULC^*)^\alpha(ULC'^*)^{1-\alpha}$$

where D_1 and D_2 are the demand variables. $A(t)$ in equation (IX.1.1) is replaced by

$$A'(t)(D_1^*)^\beta(D_2^*)^\delta.$$

^{1/} For a derivation of this result, see Hymans [32].

D_1 is simply the rate of capacity utilization (Wharton index). It is assumed to represent cyclical variation in competitive factors affecting the degree of price markup. Such variations reflect changes in the elasticity of demand, which firms believe they face under varying conditions of aggregate demand. There is probably more price cutting or "holding the line" in an effort to maintain customers and sales during periods of relatively weak demand, while in periods of strong demand, there is greater readiness to raise prices.

When utilization rates are already high, rapid increases in demand can lead to supply bottlenecks, thus raising prices. Moreover, at some output level marginal cost must begin to rise above average cost. We have thus introduced, in addition to the level of capacity utilization, a second term (D_2), which purports to reflect these effects. This term involves interaction between the relative change in final demand and a nonlinear function of capacity utilization.

There remains the problem of specifying final demand. One cannot represent shifts in final demand simply by changes in either constant-dollar or current-dollar final sales. A realized change in real sales embodies movement along a demand schedule as well as a shift in the schedule, unless demand is inelastic. Use of current-dollar sales, however, would imply a (negative) unitary price elasticity of demand. As a solution to this dilemma, a global price elasticity of demand e_p was estimated by simulation with the real sector of the model, treating prices as exogenous and determining the single period effect of a proportionate change in all final demand implicit deflators; $e_p = -.44$ for the quarter of simulation (1965-IV). Using this estimated elasticity, the change in final demand is represented by

$$(P/P_{-1})^{0.44} (S/S_{-1}),$$

where S is real final sales. The full expression for D_2 is then:

$$D_2 = \left[\frac{1}{(1 - CUW'_{-1})} \left(\frac{P}{P_{-1}} \right)^{0.44} \left(\frac{S}{S_{-1}} \right) \right]^\lambda.$$

CUW' is defined to equal the Wharton Index of Capacity Utilization (CUW), if the latter lies between 0.88 and 0.97; it is fixed at 0.88 for utilization below this rate and at 0.97 when above. The lower bound is based on the assumption that, except at high levels of utilization, bottlenecks are absent and marginal cost schedules are flat. The upper limit prevents unrealistically large price increases from occurring at extremely high utilization rates.

Component price deflators

Compared with the overall deflator equation, those for final demand component deflators are more empirical in their formulations. They are related either to an overall deflator--the private nonresidential GNP deflator of the personal consumption expenditure deflator--or to the wage rate and in some cases to certain other variables. Where a component deflator is related simply to the overall deflator, the equation merely defines what appears to be a fairly stable relative price behavior.

The change in the nonauto consumer durables deflator [equation (IX.3)] is related to the change in the overall deflator and to the level of unfilled orders of manufactured durables, which is regarded as a proxy variable for excess demand. The consumer nondurables deflator [equation (IX.4)] is related both to the overall deflator and to the index of prices received by farmers (which is associated primarily with the food component of nondurables and is treated exogenously). The consumer nonhousing services deflator [equation (IX.5)] is related to the wage rate in relative change form. The housing services deflator [equation (IX.6)] is made a function of the overall consumption deflator, the per capita stock of multifamily houses, and per capita consumption of nondurable goods and services. This last variable is used as a proxy for permanent income.

The deflator for residential construction outlays is derived in two steps: One equation (IX.8) determines the construction cost index from the overall deflator and the ratio of total real fixed investment to potential private output (used as a demand pressure variable); a second equation (IX.10) translates the cost index into the implicit deflator for residential structures. An adjusted construction cost index, used in the housing starts equation, is defined by equation (IX.9). This approximately corrects the Boeckh index for productivity change.^{2/} The deflator for fixed nonresidential investment [equation (IX.11)] is related in change form to the overall deflator and the lagged wholesale price index for manufacturing durables. The latter index [equation (IX.12)] is, in turn, a function of the ratio of unfilled orders to shipments (again, as a demand pressure variable) and the overall deflator. This index is also used to reflate the constant-dollar change in business inventories.

Equation (IX.13) defines the deflator for government "goods" purchases (total purchases less employee compensation) as a function of the overall deflator. The deflator for government compensation reflects wage rates in the government sector, which are determined by legislation. It is thus in the nature of a policy variable and is therefore made exogenous. Deflators for purchases of autos and parts, imports, and exports are exogenous for lack of suitable equations.

Wage rate

The model has a single wage rate function for the total private sector (IX.14). It is a variant of the Phillips-Lipsey [51], [41] form. The main determinants of the relative change in the money wage rate is the inverse of the unemployment rate, the change in the unemployment rate, and the lagged relative change in the implicit deflator for personal consumption expenditures. There is also a variable reflecting the composition of unemployment, namely the ratio of unemployed males, aged 25 to 54 years, to total unemployment.

^{2/} The Boeckh index is simply a weighted average of wage and material costs in construction.

The relationship of wage rate changes to the level and change in the unemployment rate is broadly consistent with recent attempts to justify the Phillips curve in terms of microeconomic behavior (see Phelps [50] and Holt [29]). Phelps, in particular, argues that the level of unemployment and change in the employment rate jointly substitute for unemployment and vacancy rates. ^{3/} However, the change in the employment rate, when tried, was not significant and thus its complement, the change in the unemployment rate, is used instead. The latter can also be justified partly by the short-run immobility of labor, since local labor shortages, and hence wage pressures, can eventually be alleviated by workers' mobility. The nonlinear--specifically, hyperbolic--shape of the wage change-unemployment rate relationship is consistent with the fact that at low unemployment rates jobs are not easily filled out of unemployed labor, while job vacancies can rise indefinitely. At high unemployment rates, on the other hand, changes in vacancies tend to correspond more closely with changes in unemployment. The distributed lag on the level of the unemployment term was set a priori (with some trial and error) because of the strongly nonlinear form.

The lagged relative change in the consumption deflator probably plays a multiple role. First, there is the overt role that the consumer price index (CPI), for which the consumption deflator is a substitute, plays in collective bargaining. The Phillips curve literature often stresses this role. Increases in the CPI are explicitly referred to in contract negotiations. Unions press for wage increases on this basis, even where formal escalator clauses are absent from the contract. Past price increases represent to the worker whose hourly pay has not risen for some period declines in real wages. Furthermore, they generate expectations of future price increases. At the same time inflationary expectations make management more confident that it can pass on the cost of new wage increases in the immediate future. Since management's concern is with product prices, including those of nonconsumption goods, changes in the consumption deflator serve only as a proxy for firms' price expectations.

Similarly, unorganized labor's wage increases can be induced by price increases, insofar as they represent realized or expected shifts in marginal revenue product schedules of firms. This impact may be reinforced by firms' expectations of a generally rising wage level and the consequent need to raise its own wages in order to remain competitive.

Price movements may also capture the possible independent effects of profits on wage rates, which some writers, notably Perry [49] and Holt [29], stress in analyzing the wage impact of collective bargaining. In the presence of the price variable, however, profits or a profit rate tend to be nonsignificant.

^{3/} Collection of job vacancy statistics has begun only recently; thus there are not sufficient observations for a usable sample period.

There are a few additional distinctive features in our wage function. First, the wage rate is defined as wages and salaries plus other labor income per employee, rather than compensation per man-hour, as in most other models. As noted above, exclusion of employer contributions from the numerator, but not from unit labor cost used in the price equation, implies that, at least in money terms, such contributions are fully passed forward.

For the denominator of the wage rate we have employment rather than man-hours because of the relative crudeness of aggregate hours data. To compensate for this specification we include as an explanatory variable the relative change in hours of manufacturing production workers. The latter is a more reliable series and accounts for most of the short-run variability in global hours. The estimated elasticity of the wage rate with respect to manufacturing hours is less than one, as would be expected.

Finally, changes are expressed in relation to the average of the preceeding four quarters, rather than the four-quarter lagged value used in our earlier formulation. The present procedure guards against seasonal repetition of erratic elements in past wage rate changes in multiple-period predictions. However, it does not circumvent the problem of serial correlation inherent in the use of overlapping changes.

Appendix: Estimation of Overall Price Deflator Equation

Estimation of the overall price deflator equation (IX.1) is complicated by: (1) The fact that the combined sum of long-run elasticities of price with respect to the two unit labor cost variants is constrained to be unity; and (2) the fact that two demand-pressure proxy variables, each with potentially independent lag distributions, are included as well. Thus, rather than using the Almon procedure, we experimented with alternative sets of a priori relative lag weights with the restrictions that one (common) set of weights applies to the two labor cost variables and another set to the two demand variables. Among the combinations tried, the chosen sets are optimal in terms of goodness of fit. That the mean lag on unit labor cost is longer than that for the demand terms seems reasonable.

When the equation was estimated with a Cochrane-Orcutt transformation, the second demand term took on a wrong (negative) sign and was nonsignificant. Since we have a strong a priori belief that such a term should be included, the untransformed regression is used.

Implicit price deflator, private nonresidential output

$$\begin{aligned}
 \text{(IX.1)} \quad \log P' - \sum_0^4 w_i \log ULC_{-i} &= .1894 + .677 \sum_0^4 w_i \log (ULC'/ULC)_{-i} \\
 &\quad (29.9) \quad (8.4) \\
 &+ .0958 \sum_0^4 w_i \log CUW_{-i} - .000232 T531 \\
 &\quad (3.7) \quad (13.6) \\
 &+ .0123 \sum_0^4 w_i \left[-\log (1-CUW_{-1}) + .44 \log (P/P_{-1}) \right. \\
 &\quad \left. + \log (X-II)/(X-II)_{-1} \right]_{-i}
 \end{aligned}$$

$$\text{where} \quad CUW' = \begin{cases} 0.97, & CUW > .97 \\ CUW, & 0.88 \leq CUW \leq 0.97 \\ 0.88, & CUW < 0.88 \end{cases}$$

$$ULC = (W-WG+SIB)/X$$

$$ULC' = [WR + (SIB/(EW-EG))] / X / (E'-EE)$$

$$E' = EP (X/XP)^{.454}$$

$$P' = \hat{P} - (TIF+TISL-TIRE)/X$$

<u>i</u>	<u>w</u>	<u>w'</u>
0	.20	.40
1	.30	.25
2	.25	.17
3	.15	.11
4	.10	.07

$$\sum 1.00 \quad 1.00$$

$$\bar{R}^2 = .996, \overline{SEE} = .00231, SE.N(P) = .0046, DW = .62$$

Implicit price deflator, gross private nonresidential output (identity)

$$(IX.2) \quad P = (PC \cdot C + PIH \cdot IH + PISE \cdot ISE + IIDOL + EXP - \\ PIM(IMT+IMS) - IMG + GFD + GFND + GSL - WG) / X$$

Implicit price deflator, consumption of nonauto durables

$$(IX.3) \quad \log (PDNA/PDNA_{-1}) = \underset{(3.1)}{-.01346} + \underset{(3.2)}{.400} \log (\hat{P}/P_{-1})$$

$$+ \underset{(3.0)}{.00750} \log UMD_{-1}$$

$$\bar{R}^2 = .314, \overline{SEE} = .0016, SE.N(PDNA) = .0044, DW = 1.15$$

Implicit price deflator, consumption of nondurables

$$(IX.4) \quad \log (PN/PN_{-1}) = \underset{(2.0)}{.000524} + \underset{(5.2)}{.530} \log (\hat{P}/P_{-1})$$

$$+ \underset{(4.8)}{.0913} \log (PF/PF_{-1})$$

$$\bar{R}^2 = .561, \overline{SEE} = .0013, SE.N(PN) = .0031, DW = 1.79$$

Implicit price deflator, consumption of nonhousing services

$$(IX.5) \quad \log (PSNH/PSNH_{-1}) = \underset{(1.8)}{.0009919} + \sum_0^6 w_i \log (WR_{-i}/WR_{-i-1})$$

<u>i</u>	<u>w</u>
0	.113
1	.105
2	.094
3	.080
4	.064
5	.045
6	.024
Σ	.524

$$\bar{R}^2 = .246, \overline{SEE} = .0014, SE.N(PSNH) = .0032, DW = 1.30$$

Implicit price deflator, consumption of housing services

(IX.6)

$$\log PH = \underset{(16.3)}{.04631} + \sum_0^5 \underset{(12.1)}{w_i} \log PC_{-i} - \underset{(12.1)}{.198} \log \overline{KH3/N3}_{-1:4} \\ + \underset{(4.3)}{.220} \log (\overline{CSNH+CN+CH})/N_{-0:3} + .80 \hat{u}_{-1}$$

<u>i</u>	<u>w</u>
0	.119
1	.136
2	.133
3	.109
4	.065
5	.000
Σ	.561

$$\overline{R}^2 = .990, \overline{SEE} = .00087, SE.N(PH) = .0065, DW = 1.65$$

Implicit price deflator, personal consumption expenditures

$$(IX.7) \quad PC = (PA \cdot CA + PDNA \cdot CDNA + PN \cdot CN + PSNH \cdot CSNH + PH \cdot CH) / C$$

Cost index, housing construction

$$(IX.8) \quad \log (PHC/\overline{PHC}_{-1:4}) = \underset{(2.2)}{.04026} + \underset{(4.3)}{.885} \log (\hat{P}/\overline{P}_{-1:4})$$

$$+ \underset{(2.1)}{.0472} \log (IH+ISE)/XP$$

$$\overline{R}^2 = .298, \overline{SEE} = .0051, SE.N(PHC) = .013, DW = .49$$

Adjusted cost index, housing construction

$$(IX.9) \quad PHCA = PHCA_{-1} (PHC/PHC_{-1} - .0025)$$

Implicit price deflator, investment for residential structures

$$(IX.10) \quad \text{PIH} = .351 + .615 \text{PHG}_{-1} + .00182 \text{T531} + .57 \hat{u}_{-1}$$

(10.9) (4.4)

$$\bar{R}^2 = .996, \overline{\text{SEE}} = .0069, \text{DW} = 1.64$$

Implicit price deflator, nonresidential fixed investment

$$(IX.11) \quad \log (\text{PISE}/\text{PISE}_{-1}) = .0004363 + .457 \log (\hat{P}/P_{-1})$$

(1.3) (3.5)

$$+ .525 \log (\text{PWMD}_{-1}/\text{PWMD}_{-2})$$

(5.9)

$$\bar{R}^2 = .528, \overline{\text{SEE}} = .0017, \text{SE.N(PISE)} = .0037, \text{DW} = 1.88$$

Wholesale price index, manufacturers' durable goods

$$(IX.12) \quad \log (\text{PWMD}/\text{PWMD}_{-1}) = .001304 + .225 \log (\hat{P}/P_{-1})$$

(2.1) (1.3)

$$+ .0137 \log (\text{UMD}/\text{SMD})_{-1} + .47 \hat{u}_{-1}$$

(23.2)

$$\bar{R}^2 = .369, \overline{\text{SEE}} = .00207, \text{SE.N(PWMD)} = .0050, \text{DW} = 1.82$$

Implicit price deflator, government purchases of goods and services

$$(IX.13) \quad \log \text{PGG} = -.01146 + 1.0377 \log \hat{P} + .00031 \text{T}' + .77 u_{-1}$$

(.96) (10.8) (.54)

$$\text{where } \text{T}' = \begin{cases} \text{T531, 1953-II to 1959-II} \\ 26.0, 1959-III to 1968-IV \end{cases}$$

$$\bar{R}^2 = .987, \overline{\text{SEE}} = .0040, \text{SE.N(PGG)} = .013, \text{DW} = 1.86$$

Wage rate (labor income per private employee)

$$\begin{aligned}
 \text{(IX.14)} \quad \overline{WR} / \overline{WR}_{-1:4} &= \underset{(2.0)}{-.443} + \underset{(5.7)}{.00116} \quad 1 / \sum_0^4 w_i \overline{UR}_{-i} - \underset{(2.9)}{.447} (\overline{UR} - \overline{UR}_{-1:4}) \\
 &- \underset{(1.8)}{.0326} \overline{UP/U}_{-0:3} + \underset{(6.4)}{.678} \overline{HM/HM}_{-1:4} \\
 &+ \underset{(4.3)}{.769} \overline{PC}_{-1} / \overline{PC}_{-2:5}
 \end{aligned}$$

<u>i</u>	<u>w</u>
0	.20
1	.35
2	.25
3	.15
4	.05
Σ	1.00

where $UP = URP \cdot LFP$

$U = LFP + LFS - EW - EE$

$\overline{R}^2 = .776$, $\overline{SEE} = .0063$, $SE.N(WR) = .027$, $DW = 1.61$

IX. Definitions of Symbols

C	Personal consumption expenditures, billions of 1958 dollars
CA	Personal consumption expenditures, autos and parts, billions of 1958 dollars
CDNA	Personal consumption expenditures, nonauto durable goods, billions of 1958 dollars
CH	Personal consumption expenditures, housing services, billions of 1958 dollars
CN	Personal consumption expenditures, nondurable goods, billions of 1958 dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
CUW	Utilization rate of industrial capacity for manufacturing, mining and utilities, Wharton index, decimal
*EE	Self-employed, millions
*EG	General civilian government employment, millions
EP	Potential private civilian employment, millions
EW	Civilian wage and salary employment, millions
*EXP	Exports, billions of dollars
*GFD	Government purchases of goods and services, Federal defense, billions of dollars
*GFND	Government purchases of goods and services, Federal nondefense, billions of dollars
*GSL	Government purchases of goods and services, State and local, billions of dollars
HM	Average weekly hours of production workers in manufacturing establishments
IH	Investment in residential structures, billions of 1958 dollars
II	Change in business inventories, billions of 1958 dollars

IIDOL	Change in business inventories, billions of dollars
*IMG	Military imports of goods and services, billions of dollars
IMS	Imports of nonmilitary services, billions of 1958 dollars
IMT	Merchandise imports, billions of 1958 dollars
ISE	Nonresidential fixed investment, billions of 1958 dollars
KH3	Stock of multifamily housing units at end of quarter, billions of 1958 dollars
LFP	Primary civilian labor force (males aged 25-54), millions
LFS	Secondary civilian labor force (total minus primary), millions
*N	Total population, millions
*N3	Population aged 20-24 and over 65, millions
. P	Implicit price deflator, private nonresidential output, 1958 = 1.000
*PA	Implicit price deflator, personal consumption expenditures, autos and parts, 1958 = 1.000
PC	Implicit price deflator, personal consumption expenditures, 1958 = 1.000
PDNA	Implicit price deflator, personal consumption expenditures, nonauto durable goods, 1958 = 1.000
*PF	Index of prices received by farmers for all farm products, 1910-14 = 1.000
PGG	Implicit price deflator, government purchases of goods, 1958 = 1.000
PH	Implicit price deflator, personal consumption expenditures, housing services, 1958 = 1.000
PHC	Index of residential construction costs, 1957-59 = 1.000
PHCA	Index of residential construction costs, adjusted, 1957-59 = 1.000
PIH	Implicit price deflator, investment in residential structures, 1958 = 1.000
*PIM	Implicit price deflator, imports, 1958 = 1.000
PISE	Implicit price deflator, nonresidential fixed investment, 1958 = 1.000
PN	Implicit price deflator, personal consumption expenditures, nondurable goods, 1958 = 1.000

PSNH	Implicit price deflator, personal consumption expenditures, nonhousing services, 1958 = 1.000
PWMD	Wholesale price index, manufacturers' durable goods, 1957-59 = 1.000
SIB	Employer contributions for social insurance, billions of dollars
SMD	Manufacturers' shipments of durable goods, billions of 1958 dollars
*T531	Time in quarters, 1953-I = 1.0
TIF	Indirect business tax and nontax liability, Federal, billions of dollars
*TIRE	Real estate taxes, billions of dollars
TISL	Indirect business tax and nontax liability, State and local, billions of dollars
UMD	Manufacturers' unfilled orders for durable goods at end of quarter, billions of 1958 dollars
UR	Unemployment rate for civilian labor force, decimal
URP	Unemployment rate for primary labor force, decimal
W	Wages and salaries plus other labor income, billions of dollars
*WG	Compensation of general government employees, billions of dollars
WR	Wages and salaries plus other labor income per private employee (wage rate), thousands of dollars per man year
X	Private nonresidential output, billions of 1958 dollars
XP	Potential private nonresidential output, billions of 1958 dollars

*exogenous

X. NATIONAL INCOME COMPONENTS, DISPOSABLE PERSONAL INCOME, AND INCOME-PRODUCT RECONCILIATION

National income components

As noted in section VIII, private wages and salaries plus other labor income [equation (X.1)] is determined as the product of private employment (excluding self-employed) and the private sector wage rate, as defined in the previous section. General government compensation and employer contributions for social insurance, except OASDI contributions, are exogenous. Nonwage components of national income are: proprietors' income, interest income, rental income, dividends, and corporate profits (adjusted for inventory valuation and net of dividends). Equations have been developed for all items except interest income. Fortunately, this is a gradually changing variable and is heavily predetermined in the short run. Hence exogenous treatment is not a serious deficiency.

Proprietors' income [equation (X.2)] is made a function of consumption expenditures on nondurable goods and nonhousing services and of the wage rate with all variables in relative change form.^{1/} The former variable serves as a proxy for proprietors' sales. The latter is introduced to reflect a significant cost component and enters with the appropriate negative sign.

Rental income of persons [equation (X.3)] varies with housing services.

The dividend equation (X.4) is similar to Lintner's [40] in relating dividends to current corporate cash flow and lagged dividends. Lagged dividends are expressed as a four-quarter average to reflect dividend smoothing (analogous to habit persistence in consumption behavior); that is, corporations tend to keep dividend payments relatively stable, even as earnings fluctuate.

The equation for corporate profits (adjusted for changes in inventory valuation) is specified to reflect the residual nature of this income component: profits equal revenue minus wage and nonwage (mainly fixed) costs. However, since the model does not generate the relevant data for the corporate sector, we cannot use a revenue-less-cost identity per se, but must resort to a stochastic equation with aggregate (economy-wide) data as proxy variables. More specifically, we make corporate profits and inventory valuation adjustment (IVA), plus capital consumption allowances (gross cash flows plus IVA) the dependent variable of a log form equation (X.5). Serving as the corporate sales proxy, gross private nonresidential output enters the equation with a near-unitary elasticity. Profits vary negatively and sensitively with the share of wages in private GNP and positively with capacity utilization. Capacity utilization serves as a proxy for unit fixed costs, which rise during recessions and fall during expansions.

^{1/} Changes are expressed as the ratio of current quarter values to average values of the preceding four quarters. Simple first differences were tried but gave poor results.

Since profits before tax are needed to obtain corporate taxes, equation (X.6) for the inventory valuation adjustment is included. The equation for IVA has as the main explanatory variable the change in the wholesale durable manufacturing price index. Additional explanatory power is obtained by including lagged inventory change. 2/

Disposable personal income

Identities (X.7) and (X.8) derive, respectively, personal income and personal disposable income from the various wage and nonwage components of national income, contained in personal income, contributions for social insurance, personal transfers, and taxes. The latter two items are discussed in the following section.

Income-product reconciliation

All income and reconciliation items, except the statistical discrepancy are accounted for either by structural equations or exogenous treatment. This leaves the model overdetermined, unless we regard the discrepancy as an endogenous variable to be determined residually by the income-product identity [equation (X.7)], which we do. To allow the discrepancy to vary without limit, however, would ignore the constraint imposed by the essential identity of income plus reconciliation items and product. Thus, we invoke the use of two boundaries on the permissible behavior of the discrepancy: (1) Its absolute level is not permitted to exceed a fixed maximum historically observed percentage of (lagged) GNP; and (2) its maximum allowable quarterly change is set at \$1.0 billion. 3/

If an initial model solution, treating the discrepancy residually, satisfies these constraints, the model is considered solved; but if either condition is violated, the model is re-solved after making constant adjustments to the wage rate, corporate profits, and proprietors' income and employment equations, so as to eliminate the excess discrepancy. The relative adjustments to each income or income-determining component are such that about equal portions of the excess in the discrepancy are allocated to wages and corporate profits and a smaller portion to proprietors' income.

The adjustments are, however, not simply ex-post corrections to income components. Instead, they feed back into the model to get a corrected solution with altered levels of income and product and an altered income distribution. Experiments, comparing solutions using this procedure with those in which the discrepancy is exogenous and profits are determined residually show that while on the average GNP estimates are neither improved nor worsened, predictions of income components tend to be improved.

2/ The (more appropriate) lagged inventory stock was tried, but did not do as well as the change.

3/ In recent years, prior to July revisions of the national income and product accounts, the measured discrepancy has frequently been substantially higher than in later estimates. Thus, in current applications it has sometimes been necessary to extend the permissible level limits to avoid incompatibility between the change and level restrictions.

Labor income

$$(X.1) \quad W = WR (EW-EG) + WG$$

Proprietors' income

$$(X.2) \quad \log (PRI / \overline{PRI}_{-1:4}) = \underset{(1.1)}{-.006638} + \underset{(4.6)}{1.339} \log \left[(PN \cdot CN + \right. \\ \left. PSNH \cdot CSNH) / (\overline{PN \cdot CN + PSNH \cdot CSNH})_{-1:4} \right] \\ - \underset{(2.0)}{.477} \log (WR / \overline{WR}_{-1:4})$$

$$\overline{R}^2 = .244, \overline{SEE} = .00874, SE.N(PRI) = .97, DW = .75$$

Rental income of persons

$$(X.3) \quad \log RENT / \overline{RENT}_{-1:4} = \underset{(2.5)}{-.008099} + \underset{(5.5)}{1.0036} \log \left[PH \cdot CH / \overline{PH \cdot CH}_{-1:4} \right]$$

$$\overline{R}^2 = .323, \overline{SEE} = .00517, SE.N(RENT) = .25, DW = .72$$

Dividends

$$(X.4) \quad DIV = .387 + \underset{(3.0)}{.0694} (CP+DC-TCF-TCSL) + \underset{(6.9)}{.727} \overline{DIV}_{-1:4} + .5 \hat{u}_{-1}$$

$$\overline{R}^2 = .993, \overline{SEE} = .37, DW = 1.77$$

Corporate profits and inventory valuation adjustment

$$(X.5) \quad \log (CP+DC) = -1.2829 + 1.0457 \log P \cdot X - 2.103 \log$$

(6.3) (15.4) (7.1)

$$\left[(W-WG+SIB)/P \cdot X \right] + .602 \log CUW + .87 \hat{u}_{-1}$$

(7.1)

$$\bar{R}^2 = .997, \overline{SEE} = .0064, SE.N(CP) = 1.02, DW = 2.44$$

Inventory valuation adjustment

$$(X.6) \quad IVA = -164.6 \Delta PWMD - .0507 II$$

(8.8) (2.2) -1

$$\bar{R}^2 = .602, \overline{SEE} = .83, DW = 1.57$$

Personal income

$$(X.7) \quad PI = W + PRI + RENT + INB + INC + INGF + INGS L + DIV$$

+ TRP - WAMD - SIP

Disposable personal income

$$(X.8) \quad DPI = PI - TPF - TPSL$$

Income-product reconciliation

$$(X.9) \quad SD = GNP - (W + TRB + RENT + PRI + INB + CP$$

+ SIB + D + TIF + TISL - SGF - SGS L)

$$|SD| \leq \max(4.0, .0074 GNP_{-1}) = SDMAX; |\Delta SD| \leq 1.0$$

If $|SD| > SDMAX$, reset $SDADJ = SD \pm SDMAX$ according as $SD \gtrless 0$, unless $SDMAX > |SD_{-1}| + 1$

If $|\Delta SD| > 1.0$, set $SDADJ = \Delta SD \pm 1$, according as $\Delta SD \gtrless 0$.

Then the following adjustments are made, and the model is re-solved:

$$\begin{aligned} \text{adjustment to } WR &= SDADJ \times .1524 / (EW-EG)_{-1} \\ \text{adjustment to } CP &= SDADJ \times .6475 \\ \text{adjustment to } PRI &= SDADJ \times .2478 \\ \text{adjustment to } E &= SDADJ \times .3411 / WR_{-1} \end{aligned}$$

X. Definitions of Symbols

CH	Personal consumption expenditures, housing services, billions of 1958 dollars
CN	Personal consumption expenditures, nondurable goods, billions of 1958 dollars
CP	Corporate profits and inventory valuation adjustment, billions of dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
CUW	Utilization rate of industrial capacity for manufacturing, mining and utilities, Wharton index, decimal
*D	Capital consumption allowances, billions of dollars
*DC	Corporate capital consumption allowances, billions of dollars
DIV	Dividends, billions of dollars
DPI	Disposable personal income, billions of dollars
*EG	General civilian government employment, millions
EW	Civilian wage and salary employment, millions
GNP	Gross national product, billions of dollars
II	Change in business inventories, billions of 1958 dollars
*INB	Net business interest, billions of dollars
*INC	Interest paid by consumers, billions of dollars
*INGF	Net interest payments, Federal, billions of dollars
*INGSL	Net interest payments, State and local, billions of dollars
IVA	Inventory valuation adjustment, billions of dollars
P	Implicit price deflator, private nonresidential output, 1958 = 1.000
PH	Implicit price deflator, personal consumption expenditures, housing services, 1958 = 1.000
PI	Personal income, billions of dollars
PN	Implicit price deflator, personal consumption expenditures, non-durable goods, 1958 = 1.000

PRI	Proprietors' income, billions of dollars
PSNH	Implicit price deflator, personal consumption expenditures, nonhousing services, 1958 = 1.000
PWMD	Wholesale price index, manufacturers' durable goods, 1957-59 = 1.000
RENT	Rental income of persons, billions of dollars
SD	Statistical discrepancy, billions of dollars
SDADJ	Statistical discrepancy adjustment (nonzero only during forecast periods), billions of dollars
*SGF	Federal subsidies less current surplus of government enterprises, billions of dollars
*SGSL	State and local surplus of government enterprises, billions of dollars
SIB	Employer contributions for social insurance, billions of dollars
SIP	Personal contributions for social insurance, billions of dollars
TCF	Corporate profits tax liability, Federal, billions of dollars
TCSL	Corporate profits tax liability, State and local, billions of dollars
TIF	Indirect business tax and nontax liability, Federal, billions of dollars
TISL	Indirect business tax and nontax liability, State and local, billions of dollars
TPF	Personal tax and nontax payments, Federal, billions of dollars
TPSL	Personal tax and nontax payments, State and local, billions of dollars
*TRB	Business transfer payments, billions of dollars
TRP	Transfer payments to persons, billions of dollars
W	Wages and salaries plus other labor income, billions of dollars
*WAMD	Wage accruals less disbursements, billions of dollars

- *WG Compensation of general government employees, billions of dollars
- WR Wages and salaries plus other labor income per private employee (wage rate), thousands of dollars per man year
- X Private nonresidential output, billions of 1958 dollars

*exogenous

Whenever possible, equations for taxes and transfers are formulated to facilitate analysis of the effects of fiscal policy decisions. Separate equations are estimated for Federal and for State and local governments. For Federal taxes and transfers, the typical function includes base and rate variables. The specifications for some tax and transfer equations in this section are patterned after the work of Waldorf [61].

Personal tax and nontax payments

Federal personal taxes. In the national income and product accounts personal taxes are estimated on a cash rather than an accrual basis. In accordance with the institutional framework, total Federal personal tax receipts are decomposed into withheld and nonwithheld taxes. Withheld taxes are paid on the basis of current wages and salaries and hence correspond closely to accruals.

Nonwithheld income tax receipts consist of quarterly payments, made on the basis of estimated tax or "declarations," and balance-due payments less refunds or "net settlements." Net settlements are clearly based on previous years' income. Declarations are based on expected income, but in practice, these are also largely based on the previous year's income. Thus, net nonwithheld taxes are essentially predetermined for the current calendar year.

Withheld taxes. The model contains a function for Federal withholdings [equation (XI.1)]. The nearest approximation to the desired tax base in the model is labor income, i.e., the sum of wages and salaries and "other" labor income. The tax rate, however, is the effective rate based on wages and salaries alone. Thus, the elasticity of withholdings with respect to the base is less than one, while that with respect to the rate is constrained to be unity. There is also a dummy variable to reflect the introduction of graduated withholding in May 1966.

Nonwithheld taxes less refunds. Prediction of net nonwithheld Federal taxes presents unique difficulties, since this component is essentially determined (in the economic sense) on an annual basis. Nevertheless, it has a strong seasonal behavior, to which special smoothing procedures must be applied. In the operation of the model we maintain the option of forecasting net nonwithheld income taxes exogenously or deriving them from a small recursive block of equations (XI.2 to XI.8).

These equations determine successively personal taxable income and personal tax liability for the previous year, declarations for the previous and current year, and net settlements for the current year. Declarations and net final settlements, which comprise net nonwithheld income taxes, are then distributed over the current year by quarters. We shall discuss these equations and procedures in order.

Personal tax liability. Tax liability of a given year is needed both for the following year's declaration payments and for net settlements. Tax liability, in turn, is based on taxable income. To obtain taxable income [equation (XI.2)], we use a variant of Waldorf's equation [61, pp. 26-28], the form of which is taken from Brown and Kruizenka [5a]. In addition to the variables used by Brown and Kruizenka--per capita personal income, per capita exemptions, a dummy variable to reflect a shift in the relationship of adjusted gross income to personal income--we employ the annual change in the Standard and Poor stock price index to reflect crudely the effect of capital gains or losses.

An equation for Federal personal tax liability is estimated for two periods within which the tax law remained unchanged: 1954-63 and 1965-69 [equation (XI.3)]. Because the tax cut enacted in early 1964 was not fully implemented in that year, the tax function is undefined for this transitional period. In the equation for the early period the explanatory variables are the lowest bracket tax rate with (constrained) unitary elasticity and personal taxable income, which has slightly less than unitary elasticity. For the later period a multiplicative factor for the tax surcharge, in effect during a part of the period, is incorporated. The tax rate is the new first bracket rate effective under the Revenue Act of 1964. (The previous bottom bracket was subdivided into four new brackets.)

The Tax Reform Act of 1969 and the Revenue Act of 1971 introduced further legislative changes, affecting both taxable income and tax rates. Since the taxable income function explicitly incorporates personal exemptions, no adjustment is required in the function to handle the new exemption rates. However, special adjustments are required to take into account the increased standard deduction, low income, and other provisions, which also affect taxable income. Similarly, adjustment is required in the liability function because of tax reductions for unmarried individuals and heads of households and for other minor provisions. At present we lack sufficient observations to determine the appropriate parameter adjustments to each function, and so, we must resort to exogenous treatment in forecasting applications.

Declarations and net settlements. Payments on estimated tax for a given year are made in April, June, September, and the following January. While April, June, and September payments in any year are nearly equal, January payments are often substantially higher. In effect, January payments contain year-end settlements that are paid to avoid penalties incurred by under-declared estimated taxes. Thus, we estimate declaration payments for a given year (T) as the sum of April, June, and September payments during year T plus the portion of the following January payments, equal to the average of these payments, i.e., the last three declaration payments of calendar year blown up by a factor of 1-1/3. The residual of the January payment is added to net settlements paid in year T + 1. Declarations are made a function of the previous year's liability and withholdings [equation (XI.4)]. A dummy variable is introduced to allow for changed rules for making declaration payments beginning in 1966.

Year-end settlements less refunds are obtained in equation (XI.5) which approximates the identity:

$$(\text{net settlements})_T = (\text{liability} - \text{withholdings} - \text{declarations})_{T-1},$$

where the subscript T denotes an annual time period. The identity does not hold exactly, since net settlements do not pertain exclusively to the prior years' liability. Total nonwithheld income taxes for year T is given by the identity (XI.6).

Quarterly distribution of nonwithheld taxes. The problem of distributing nonwithheld taxes over the year by quarters in an accounting framework that requires seasonally adjusted data remains. Since year-end settlements and refunds, which account for most within-year variability in nonwithheld taxes, are transacted almost entirely during the first half of the year, usual methods of seasonal adjustment do not apply. Instead, a smoothing procedure, designed to eliminate both seasonality and discontinuities in the data from the last quarter of one year to the first quarter of the next, applies.

In the model we attempt to duplicate (approximately) the smoothing procedure used for deseasonalizing the data in the national income accounts. Specifically, we use the "Liebenberg-Kaitz" formula, which involves application of sets of weights to estimated values of the variable for three successive years, centered on the current year (T) and the fourth quarter value for year T - 1. 1/

In running the model, we naturally have no estimate for year T + 1 at the point where nonwithheld taxes must be spread over year T. Thus, we assume for T + 1 a value implied by the average annual growth rate for nonwithheld taxes--about 1.2 percent for the period 1954-64. Since the T + 1 weights are invariably small, the error introduced by this assumption is negligible. (After 1964 the pattern of nonwithheld taxes is seriously disrupted because of changes introduced by the Revenue Act of 1964 and the institution of graduated withholdings in 1966, so that "normal" growth cannot be measured from this point.) Weights used in the quarterly distribution of nonwithheld taxes are shown in equation (XI.7). The set of four weights found in each equation of the original Liebenberg-Kaitz formula collapse to three because of the growth rate assumption (i.e., the weight on $TPFN_T = w_3 + 1.012 w_4$, where w_3 is the weight on Y_T and w_4 is the weight on Y_{T+1} in the original formula).

1/M. Liebenberg and H. Kaitz, "Chain Formula to Obtain Quarterly Estimates from Annual Data," Technical Note No. 1 (BEA internal staff memorandum). This method has general applicability to series where (1) no quarterly information is available or usual seasonal adjustment methods do not apply, and (2) a suitable indicator series for quarterly interpolation does not exist. The weights are derived by assuming that a cubic function adequately describes the desired smooth curve. The formula weights are derived by setting the areas under the polynomial equal to each of the annual totals for the given and adjacent years and the last quarter of the previous year. The last condition is introduced to assure continuity with values previously derived. The procedure obviously requires an initial extraneously determined fourth-quarter figure in order to begin the series.

The above procedure may be modified to allow for an "abnormal" change in net settlements, due to a change in the tax law, such as occurred in 1964 and 1969. In this case nonwithheld taxes are computed quarterly for year T, based on tax laws in force in year T - 2. The excess or deficit of TPFN, based on the new tax law compared with the old, is then distributed evenly over the first half of year T and added to smoothed TPFN values, based on the old law.

Finally, total Federal personal tax and nontax payments are obtained on a quarterly basis as the sum of withheld and nonwithheld income taxes and estate and gift taxes, plus nontax payments [equation (XI.8)].

State and local personal taxes. Personal tax and nontax payments to State and local governments consist of income and non-income related taxes. The income component is fitted over two subperiods--1953-II through 1965-III and 1965-IV through 1968-IV [equation (XI.9)]. The marginal tax rate increases substantially after 1965. Non-income taxes are added exogenously to yield total tax and nontax payments.

Corporate tax liability

Federal corporate taxes. Corporate income taxes are estimated on a liability basis in the national income and product accounts. This variable is predicted using equation (XI.11). Because of infrequent changes in the rate during the sample period (1954, 1964, and 1965), the elasticity of the tax rate cannot be estimated reliably and is constrained a priori to unity. The elasticity of the base--profits before tax--is determined statistically and is slightly greater than unity. The dependent variable in the logarithmic equation form is corporate tax liability plus investment tax credit (zero before 1962). The second component represents a deduction from tax liability. A dummy variable is included to reflect the excess profits in force during 1953.

State and local corporate taxes. State and local corporate taxes [equation (XI.12)] are linearly related to profits before tax and have a slight but significantly positive time trend. The trend apparently reflects modest net increases in effective tax rates.

Indirect business taxes

Federal indirect taxes. Federal indirect taxes are divided into three components: (1) major specific excise taxes (liquor, tobacco products, and gasoline), (2) major ad valorem taxes (autos, trucks, telephone and telegraph), and (3) "other" Federal indirect taxes. In Waldorf's study [61, Ch. IV], both demand functions and revenue functions for excise taxes on individual commodities are developed. When those functions are combined, partially reduced forms, relating revenue to income or GNP and sometimes to relative prices, are obtained. The model equations [(XI.13) and (XI.14)] for the combined groups of specific and ad valorem excise taxes use weighted averages of individual tax rates. Because excise taxes are aggregated and certain commodities appear as intermediate goods sales, as well as final product, the broad final sales aggregates serve as rather crude proxy variables for the tax base. Constant-dollar goods sales are used as the tax "base" for specific excise taxes; current-dollar sales of private goods and services are used as the base for ad valorem taxes.

It should be noted, however, that these variables cannot be interpreted strictly as proxies for the tax base, since sales are correlated with income. Hence, the corresponding estimated elasticities reflect also the demand for these commodities via the income effect. The residual, "other" Federal indirect taxes, representing mainly other excise taxes and custom duties, is relatively small and stable and is made exogenous.

State and local indirect business taxes. State and local indirect business taxes consist of sales taxes and nonsales taxes (primarily real estate taxes). The sales component is regressed on final sales over two subperiods: 1953-66 and 1967-68 [equation (XI.16)]. The higher slope in the second period reflects widespread increases in State and local sales tax rates. The nonsales tax component is added exogenously to the sales component to yield total indirect taxes.

Social security contributions

A single equation (XI.18) is used for total employer-employee OASDHI (social security) contributions plus (since 1966) hospital insurance (Medicare) premiums, which are contributed in equal amounts by employers and employees. As in other tax equations the basic variables are the tax rate and a tax base--in this case private labor income. In addition, payments have to be modified, when maximum taxable earnings are increased and when coverage is extended. Maximum taxable earnings are included explicitly in the equation, and a dummy variable is inserted for the substantial increases in coverage that occurred in 1954 and 1956. The elasticity of contributions with respect to wages is significantly below unity, primarily because of the ceiling imposed on such taxes by maximum taxable earnings.

All other contributions to social insurance--Federal (including social security contributions of self-employed persons) and State and local--are treated exogenously.

State unemployment insurance benefits

Among transfers to persons State unemployment insurance benefits are notably countercyclical in their behavior. An equation for this component (XI.21) is thus included in the model, while other transfers are left exogenous. Total transfers are given by the identity (XI.22). As in the Federal tax equations, the relation contains base and rate variables which are, respectively, the level of civilian unemployment (strictly, only insured unemployment should be included) and a weighted average weekly benefit rate for the twenty largest states in terms of covered employment. In addition, an adjustment factor and a dummy variable are included to reflect temporarily extended benefits in 1958 and 1961-62.

Fiscal balance

Identities (XI.23) and (XI.24) yield the fiscal surplus or deficit (receipts minus expenditures) for Federal and State and local governments on a national income accounts basis.

Equations for Section XI

Federal personal withheld taxes (quarterly)

$$(XI.1) \quad \log \text{TPFW} = .0190 + .981 \log W + \log \text{RTFW} + .00325 \text{ DGW} \\ (4.2) \quad (527.3) \quad (5.6)$$

$$\bar{R}^2 = 1.00, \overline{SEE} = .00116, DW = 1.22$$

Personal taxable income (annual)

$$(XI.2) \quad \log [1 - (\text{PIT}/(\text{PI} + \text{SIP} - \text{TRP}))] - .35 \log (\text{TPFE}/N) = .0153 \\ (3.0) \\ - .4936 \log ((\text{PI} + \text{SIP} - \text{TRP})/N) - .0342 \log (\text{SM}/\text{SM}_{-1}) \\ (29.1) \quad (1.5) \\ + .00648 \text{ DPIT} \\ (2.2)$$

$$\bar{R}^2 = .990, \overline{SEE} = .0039, DW = 1.56$$

Federal personal tax liability (annual)

1954 - 1963

$$(XI.3a) \quad \log \text{TPFL} - \log \text{RTPF} = .1137 + .981 \log \text{PIT} \\ (79.1)$$

$$\bar{R}^2 = .999, \overline{SEE} = .0030, DW = 1.50$$

1965 - 1969

$$(XI.3b) \quad \log \text{TPFL} - \log \text{RTPF} - \log \text{RSCH} = .0058 + 1.06 \log \text{PIT} \\ (28.3)$$

$$\bar{R}^2 = .955, \overline{SEE} = .0058, DW = 2.58$$

Federal declarations (annual)

$$(XI.4) \quad TPF D = .294 \underset{(2.9)}{TPFL} -1 - .131 \underset{(1.0)}{TPFW} -1 - .552 \underset{(1.1)}{DDEC} + .51 \hat{u}_{-1}$$

$$\bar{R}^2 = .910, \overline{SEE} = .54, DW = 1.63$$

Federal net tax settlements (annual)

$$(XI.5) \quad TPFS = 2.05 + .909 \underset{(16.0)}{TPFL} -1 - .869 \underset{(15.4)}{(TPFW + TPF D)} -1$$

$$\bar{R}^2 = .952, \overline{SEE} = .20, DW = 2.25$$

Total nonwithheld taxes (annual)

$$(XI.6) \quad TPFN = TPFS + .75 TPF D + .25 TPF D_{-1}$$

Quarterly distribution of Federal nonwithheld income taxes
(T=year, t=quarter)

$$\begin{aligned} (XI.7) \text{ First quarter: } & TPFN_t = -.181 TPFN_{T-1} + .778 TPFN_{t-1} + .403 TPFN_T \\ \text{Second quarter: } & TPFN_t = -.153 TPFN_{T-1} + .289 TPFN_{t-2} + .863 TPFN_T \\ \text{Third quarter: } & TPFN_t = .028 TPFN_{T-1} + .289 TPFN_{t-3} + 1.26 TPFN_T \\ \text{Fourth quarter: } & TPFN_t = .306 TPFN_{T-1} - .778 TPFN_{t-4} + 1.47 TPFN_T \end{aligned}$$

Total Federal personal tax and nontax payments

$$(XI.8) \quad TPF = TPF W + TPFN + TPF R$$

State and local personal income taxes

1953-II to 1965-IV:

$$(XI.9a) \quad TP SLI = -3.1 + .0147 \underset{(59.6)}{(PI + SIP - TRP)}$$

$$\bar{R}^2 = .986, \overline{SEE} = .13, DW = .90$$

1966-I to 1968-IV:

$$(XI.9b) \quad TP SLI = -10.8 + .028 (PI+SIP-TRP) \\ (30.0)$$

$$\bar{R}^2 = .989, \overline{SEE} = .13, DW = .90$$

State and local personal taxes

$$(XI.10) \quad TP SL = TP SLI + TP SLNI$$

Federal corporate taxes

$$(XI.11) \quad \log (TCF+TCRI) - \log RTCF = -.0932 + 1.0074 \log (CP-IVA) \\ (6.3) \quad (119.3) \\ + .0458 DTCF \\ (9.8)$$

$$\bar{R}^2 = .996, \overline{SEE} = .0076, SE.N(TCF) = .46, DW = .95$$

State and local corporate taxes

$$(XI.12) \quad TC SL = -.306 + .0240 (CP-IVA) + .0128 T531 \\ (10.4) \quad (6.1)$$

$$\bar{R}^2 = .96, \overline{SEE} = .125, DW = .44$$

Federal specific excise taxes

$$(XI.13) \quad \log TEXS = -1.677 + 1.627 \log RTEXS + .977 \log (X-II-CSNH) \\ (15.1) \quad (17.8) \quad (22.1)$$

$$\bar{R}^2 = .98, \overline{SEE} = .0163, SE.N(TEXS) = .25, DW = .74$$

Federal ad-valorem excise taxes

$$(XI.14) \quad \log TEXAV = -2.736 + .818 \log RTEXAV + 1.190 \log P(X-II) \\ (11.6) \quad (3.8) \quad (13.1)$$

$$\bar{R}^2 = .855, \overline{SEE} = .0407, SE.N(TEXAV) = .22, DW = 1.37$$

Federal indirect taxes

$$(XI.15) \quad TIF = \text{TEXS} + \text{TEXAV} + \text{TIFO}$$

State and local sales taxes

1953-II to 1966-IV:

$$(XI.16a) \quad \text{TISLS} = -5.8 + .0104 \text{ P(X-II)} \\ (104.)$$

$$\bar{R}^2 = .995, \overline{\text{SEE}} = .25, \text{DW} = .37$$

1967-I to 1968-IV:

$$(XI.16b) \quad \text{TISLS} = -16.9 + .0577 \text{ P(X-II)} \\ (19.3)$$

$$\bar{R}^2 = .982, \overline{\text{SEE}} = .26, \text{DW} = 1.71$$

State and local indirect taxes

$$(XI.17) \quad \text{TISL} = \text{TISLS} + \text{TISLNS}$$

OASDI contributions

$$(XI.18) \quad \log \text{TSSW} - \log \text{RTSSW} = -1.311 + .807 \log (\text{W-WG}) \\ (19.6) \quad (31.0)$$

$$+ .451 \log \text{MAXSS} + .00753 \text{ DTSSW} \\ (13.9) \quad (2.9)$$

$$\bar{R}^2 = .996, \overline{\text{SEE}} = .0082, \text{SE.N(TSSW)} = .21, \text{DW} = .81$$

Personal contributions for social insurance

$$(XI.19) \quad \text{SIP} = .5 \text{ TSSW} + \text{SIPOF} + \text{SIPSL}$$

Employer contributions for social insurance

$$(XI.20) \quad \text{SIB} = .5 \text{ TSSW} + \text{SIBOF} + \text{SIBSL}$$

State unemployment benefits

$$(XI.21) \quad \log TRU - \log TRUEX = -1.128 + .458 \log RTRU$$

$$(10.4) \quad (6.5)$$

$$+ 1.360 \log (LFP + LFS - EW - EE) + .0749 DTRU$$

$$(22.4) \quad (3.2)$$

$$\bar{R}^2 = .934, \overline{SEE} = .0411, SE.N(TRU) = .20, DW = .92$$

Transfer payments to persons

$$(XI.22) \quad TRP = TRU + TRPOF + TRPSL + TRB$$

Federal fiscal balance

$$(XI.23) \quad FBF = (TPF + TCF + TIF + TSSW + SIPOF + SIBOF) -$$

$$(GFD + GFND + TRU + TRPOF + TRFF + GIA + INGF + SGF)$$

State and local fiscal balance

$$(XI.24) \quad FBSL = (TPSL + TCSL + TISL + SIPSL + SIBSL + GIA) -$$

$$(GSL + TRPSL + INGS� + SGS�)$$

XI. Definitions of Symbols

CP	Corporate profits and inventory valuation adjustment, billions of dollars
CSNH	Personal consumption expenditures, nonhousing services, billions of 1958 dollars
*DDEC	Dummy for December Federal personal income tax declarations: 1966-I to 1966-IV = 0.67, 1967-I and after = 1.0; otherwise = 0.0
*DGW	Dummy to allow for graduated withholdings: 1966-II = 0.5, 1966-III and after = 1.0; otherwise = 0.0
*DPIT	Dummy for taxable income: 1953-I to 1957-IV = 0.0; otherwise = 1.0
*DTCF	Dummy for excess profits tax: 1953-I to 1953-IV = 1.0, otherwise = 0.0
*DTRU	Dummy for supplemental benefits for State unemployment transfer payments: 1958-I to 1958-IV = 1.0; otherwise = 0.0
*DTSSW	Dummy for additional coverage under social security: 1954-IV to 1966-IV = 1.0; otherwise = 0.0
*EE	Self-employed, millions
EW	Civilian wage and salary employment, millions
FBF	Federal surplus or deficit (minus) NIA basis, billions of dollars
FBSL	State and local surplus or deficit (minus) NIA basis, billions of dollars
*GFD	Government purchases of goods and services, Federal defense, billions of dollars
*GFND	Government purchases of goods and services, Federal nondefense, billions of dollars
*GIA	Federal grants-in-aid to State and local governments, billions of dollars
*GSL	Government purchases of goods and services, State and local, billions of dollars
II	Change in business inventories, billions of 1958 dollars
*INGF	Net interest payments, Federal, billions of dollars
*INGSL	Net interest payments, State and local, billions of dollars

IVA	Inventory valuation adjustment, billions of dollars
LFP	Primary civilian labor force (males aged 25-54), millions
LFS	Secondary civilian labor force (total minus primary), millions
*MAXSS	Maximum salary subject to social security deductions, dollars
*N	Total population, millions
P	Implicit price deflator, private nonresidential output, 1958 = 1.000
PI	Personal income, billions of dollars
PIT	Federal personal taxable income (annual), billions of dollars
*RSCH	Index of Federal personal income tax surcharge rates
*RTCF	Federal corporate profits tax rate, decimal
*RTEXAV	Index of average rates for Federal <u>ad valorem</u> excise taxes, 1958 = 1.000
*RTEXS	Index of average rates for Federal specific excise taxes, 1958 = 1.000
*RTFW	Effective withholding rate for Federal individual income taxes, decimal
*RTPF	First bracket tax rate for Federal individual income taxes, decimal
*RTRU	Maximum weekly benefit rate for unemployment insurance, dollars
*RTSSW	Combined employer-employee contribution rate for OASDHI, decimal
*SGF	Federal subsidies less current surplus of government enterprises, billions of dollars
*SGSL	State and local surplus of government enterprises, billions of dollars
SIB	Employer contributions for social insurance, billions of dollars
*SIBOF	Employer contributions for Federal social insurance programs (excluding OASDHI), billions of dollars
*SIBSL	Employer contributions for State and local social insurance programs, billions of dollars
SIP	Personal contributions for social insurance, billions of dollars
*SIPOF	Personal contributions for Federal social insurance programs (excluding OASDHI except self-employed), billions of dollars

*SIPSL	Personal contributions for State and local social insurance programs, billions of dollars
*SM	Standard and Poor's index of 500 stocks
*T531	Time in quarters, 1953-I = 1.0
TCF	Corporate profits tax liability, Federal, billions of dollars
*TCRI	Investment tax credit, billions of dollars
TCSL	Corporate profits tax liability, State and local, billions of dollars
TEXAV	<u>Ad valorem</u> Federal excise taxes, billions of dollars
TEXS	Specific Federal excise taxes, billions of dollars
TIF	Indirect business tax and nontax liability, Federal, billions of dollars
*TIFO	Federal nonexcise indirect business tax receipts, billions of dollars
TISL	Indirect business tax and nontax liability, State and local, billions of dollars
*TISLNS	Indirect business tax and nontax liability except sales taxes, State and local, billions of dollars
TISLS	State and local sales taxes, billions of dollars
TPF	Federal personal tax and nontax payments, billions of dollars
TPFD	Estimated tax payments, Federal (declarations), billions of dollars
*TPFE	Exemptions, Federal personal income taxes, billions of dollars
TPFL	Liabilities, Federal personal income taxes, billions of dollars
TPFN	Personal nonwithheld tax payments, less refunds, billions of dollars
*TPFR	Estate and gift tax and nontax payments, billions of dollars
TPFS	Personal tax settlements less refunds, Federal, billions of dollars

TPFW	Personal withheld taxes, Federal, billions of dollars
TPSL	State and local personal tax and nontax payments, billions of dollars
TPSLI	State and local personal income taxes, billions of dollars
*TPSLNI	State and local personal tax and monetary payments except income taxes, billions of dollars
*TRB	Business transfer payments, billions of dollars
*TRFF	Net transfer payments to foreigners, Federal, billions of dollars
TRP	Transfer payments to persons, billions of dollars
*TRPOF	Transfer payments to persons, excluding unemployment insurance benefits, Federal, billions of dollars
*TRPSL	Transfer payments to persons, State and local, billions of dollars
TRU	State unemployment insurance benefits, billions of dollars
*TRUEX	Ratio of NIA total State unemployment benefits to total minus extended benefits
TSSW	Personal and employer contributions for OASDHI, excluding self-employed and personal medical payments but including hospital insurance, billions of dollars
W	Wages and salaries plus other labor income, billions of dollars
*WG	Compensation of general government employees, billions of dollars
X	Private nonresidential output, billions of 1958 dollars

*exogenous

XII. FINANCE

The financial sector of the BEA model provides a mechanism for translating the actions of monetary authorities into a set of interest rates and asset totals, which affect the real (nonfinancial) sector. The transformation is effected by a set of structural equations and identities, which partly depend upon nonfinancial variables. Thus, the monetary and real sectors are mutually interrelated.

In the following treatment we have adopted the general framework of the financial sector used in the Federal Reserve-MIT model [8], though there are departures from its particular specification. The instruments available to the monetary authorities consist of those over which the Federal Reserve has complete or effective control. In the "effective" category is nonborrowed reserves, since, strictly speaking, the central bank has absolute control only over its holdings of Government securities. However, through "defensive" open market sales and purchases it can have effective control over an aggregate of reserves, such as nonborrowed reserves. ^{1/} Other policy variables are reserve requirements ratios, the discount rate, and the ceiling rate on time deposits. The endogenous variables of the monetary sector are liquid asset holdings and various interest rates, which feed into the real sector.

Though in the model they are treated as exogenous, the policy variables, whether they change continuously (e.g., nonborrowed reserves) or discretely (e.g., the discount rate), are to a very considerable degree endogenous, since policy behavior is responsive to what is happening both in the financial sector and the real economy.

Money market equations

The basic relationships of the "money market" portion of the financial sector are outlined in the following three simplified equations for this subsector:

- | | | |
|-----------|--------------------------------|----------------------------|
| (XII.1.1) | $RESNB = RESF + REQ \times DD$ | Reserve identity |
| (XII.2.1) | $RESF = f(R, RDIS)$ | Demand for free reserves |
| (XII.3.1) | $DD = g(R, GNP)$ | Public's demand for money, |

where RESNB is nonborrowed reserves; RESF is free reserves; REQ is the required reserve ratio; DD represents demand deposits (the largest component of the money supply); R is a general short-term interest rate; RDIS is the discount rate; and GNP is gross national product.

This simplified structure--in contrast to the actual model--omits certain additional explanatory variables and ignores the distinction among the various components of the money supply (including time deposits) and among various short-term interest rates.

^{1/} A new reserve total, which has recently become the target of monetary control, is reserves against private deposits (RPDs).

The reserve identity (XII.1.1)--(XII.1) in the actual model--equates the supply of nonborrowed reserves (total member bank reserves minus borrowings) to the sum of its components classified by use, i.e., non-borrowed reserves = net free reserves + required reserves. Net free reserves (excess reserves less member bank borrowings) represent cash available to the banking system. In reality (and in the actual model) required reserves are held against both demand and time deposits and thus vary with their level and composition.

Equation (XII.2.1) of the simplified model represents banks' demand for holding free reserves. This demand, which arises from banks' uncertainty regarding deposit variations and business loan demands, is related inversely to rates on secondary liquid assets (of which Treasury bills are a main component) and positively to the Federal Reserve discount rate.

Equation (XII.2), of the actual model corresponds to this equation, but makes the three-month Treasury bill rate the dependent variable with the discount rate, net free reserves, inventory change (before inventory valuation adjustment), and the lagged Federal fiscal balance (deflated by lagged GNP as a scaling factor) as the explanatory variables. The coefficient of the discount rate is constrained to unity because, when it is freely estimated, it is slightly larger than unity, which is a priori not reasonable. Inventory change is included as a proxy variable for bank business loan demand, which exerts additional pressure on short-term interest rates. The fiscal balance, of course, affects the bill rate via the demand for government securities.^{2/}

The money stock, defined as demand deposits adjusted plus currency, is assumed to have a stable long-run relationship to GNP but with an exponentially declining trend equation (XII.3) [corresponds to (XII.3.1) in the simplified model]. The long-run elasticity of demand for money with respect to GNP is constrained to unity by making the dependent variable the logarithm of the ratio of money stock to GNP or inverse of the income velocity of money. The relative change in GNP from the previous four-quarter mean appears with a negative fractional coefficient. Thus, in the short run the demand for money responds with less than unitary elasticity to changes in GNP. Rates on time deposits and short-term commercial paper are used to represent returns on competing assets. The rate of interest on demand deposits themselves is, of course, zero. There is a similar equation for currency [equation (XII.4)]. Thus demand deposits are determined residually from equations (XII.3) and (XII.4). Personal consumption expenditures replace GNP as the relevant transactions variable in the currency equation, and no interest rate is included.

^{2/} In a more complete financial model the bill rate, along with other short-term interest rates, would be determined implicitly from demand and supply functions for various assets by different asset holders, and there would not be this problem of inconsistency between the bill rate and free reserve interpretation of equation (XII.2) (see e.g., Brainard and Tobin [4]).

Commercial bank time deposit holdings consist largely of passbook savings accounts. They also include business accounts and since 1962 certificates of deposit. In equation (XII.5) time deposits are a function of disposable personal income and relative differences between interest rates on time deposits and on competitive instruments--Treasury bills and savings and loan accounts. The lagged dependent variable indicates a partial adjustment process.

The money market sector in the actual model determines, in addition to the 3-month Treasury bill rate, the yield on 4-6 month commercial paper, which occurs as an explanatory variable in the money demand equation. These two rates are related by an empirical equation (XII.6). A dummy shift variable is included to allow for an effect of the introduction of certificates of deposits after 1962-I.

Finally, an average rate on commercial bank time and savings deposits is required for the time deposit equation. Rates on time deposits are presumably set by banks so as to maximize net earnings, but specification of the relevant cost and earnings functions would be extremely complicated. In equation (XII.7) for the rate on time deposits a distributed lag of the ratio of free to nonborrowed reserves is used as a crude proxy for relative supply and demand pressures. The ceiling rate on time deposits, as defined by Federal Reserve Regulation Q, is included as an additional factor, and the lagged dependent variable allows for an adjustment process.

The accompanying flow chart reveals the interactions of the relationships of the simplified money market submodel. It thus indicates how the actual model works. Free reserves, the short-term interest rate and the money supply are simultaneously determined, given GNP and the instruments of monetary policy.

The effects within the submodel of a change in any monetary instrument may be traced. An increase in nonborrowed reserves, for example, increases free reserves, which tends to lower the short-term interest rate. This increases the demand for money and, with it, required reserves. Thus, free reserves fall, tending to offset the initial increase. A reduction in reserve requirements would have effects similar to those of an increase in nonborrowed reserves. Finally, a rise in the discount rate increases the short-term market interest rate, which in turn reduces the demand for money. The latter decline results in reduced required reserves and larger free reserves, which lead to a lower interest rate--again partly offsetting the impact of the initial action.

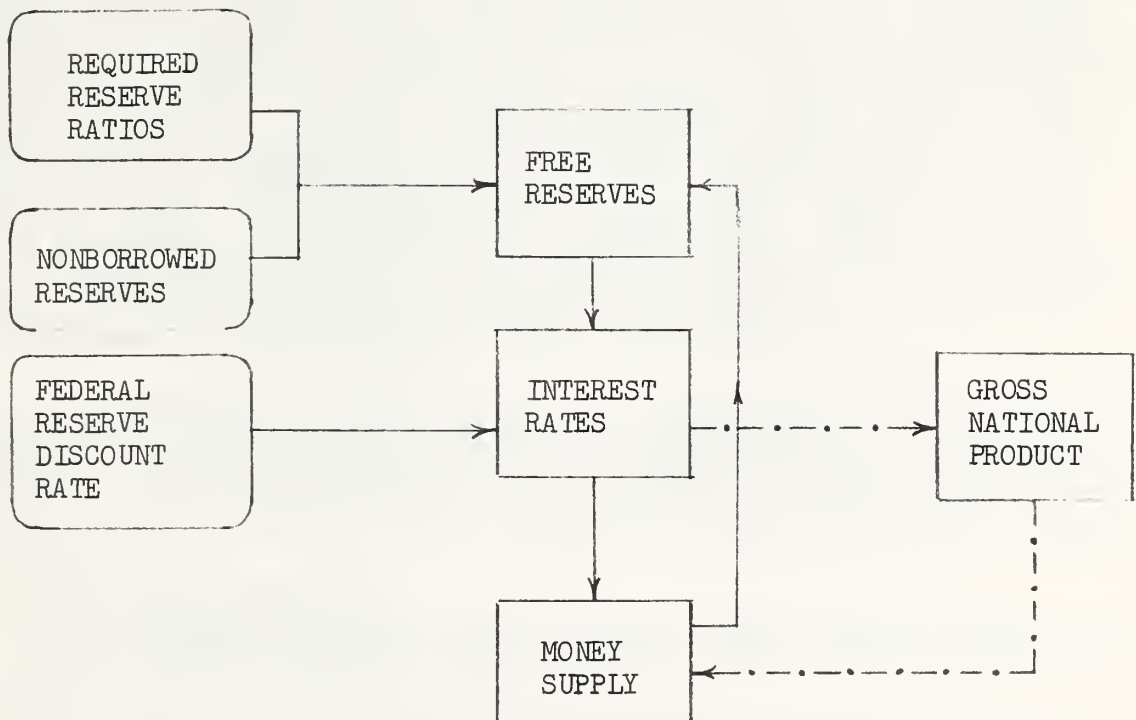
Boundary constraint on net borrowed reserves. Simulations of the above equations under various conditions during the sample period depict actual movements in interest rates and money supply fairly well. However, these equations do not allow for realistic constraints on attainable levels of net borrowed reserves. In particular, excess reserves cannot be less than zero; and Federal Reserve Regulation A limits the extent and duration of borrowing by individual member banks. This implies that aggregate net borrowed reserves cannot increase without limit. We thus impose a maximum on net borrowed reserves (or equivalently, a minimum on free reserves).

SIMPLIFIED FLOW CHART FOR

MONEY MARKET SUBSECTOR

EXOGENOUS
VARIABLES

ENDOGENOUS
VARIABLES
(OTHER SECTORS)



— current
- - - current and lagged

The minimum ratio of free reserves to lagged nonborrowed reserves is made a linear function of the lagged ratio [see condition under (XII.1)]. The parameters are determined so that the function barely accomodates the relatively high level of net borrowed reserves in 1969-II and allows for no further increase in net borrowed reserves, when the ratio of free to nonborrowed reserves is $-.041$. These conditions were derived on the basis of a scatter diagram of changes in the above reserve ratio versus the lagged level.

After the entire model has been solved without constraint, the boundary condition is tested. If the unconstrained model yields a value for free reserves which transcends the boundary condition, the solution mechanism is transferred to the constrained mode, which consists of equations (XII.1), (XII.3a) in place of (XII.3), (XII.4) through (XII.6), and (XII.7a) in place of (XII.7).

Equation (XII.2)--or in terms of the simplified model above [equation (XII.2.1)]--is dropped, since free reserves are now fixed by the boundary condition. The money stock is then effectively controlled by nonborrowed reserves, as suggested in equation (XII.1.1). In principle one could then use equation (XII.3) [(XII.3.1) in the simplified model] to solve the short-term interest rate. However, because of imperfect specification, as well as simultaneous equation bias, the inverted money demand function does not yield reliable estimates of the interest rate. Thus, equation (XII.3a) is substituted. This equation, which is expressed in terms of deviations from unconstrained solution values, is derived from a regression, which is an approximate inversion of the money demand equation with the commercial paper rate as the dependent variable. Note, however, that lagged values of the commercial paper rate are absent from this equation.

The Treasury bill rate is now solved from equation (XII.6) in renormalized form. Currency and the interest rate on time deposits are retained from the unconstrained solution. In sum, compared with an unconstrained solution: (1) The money stock will be smaller; (2) interest rates will be higher; and (3) there will be a relative shift from demand to time deposits.

Other financial equations

The remaining equations in the financial sector determine longer-term interest rates and household liquid assets.

The basic long-term interest rate, represented by Moody's average corporate bond yield, is derived from the commercial paper rate by a "rate structure" equation (XII.8). In the steady-state, under our formulation, the spread between short and long rates depends upon the level of the short rate. Dynamically, the function is assumed to have a "rational" lag structure (see Jorgenson [34]). The implied distributed lag weights on the short rate are in conformity with the Modigliani-Sutch [46] theory of rate structure determination. This theory combines regressive expectational elements, induced by short-run changes in the short rate, with extrapolative expectations, induced by longer-run changes.

There is also an equation for the mortgage yield [equation (XII.9)], which is a distributed lag function of the long-term bond yield. In addition, there is an equation for the average rate on savings and loan accounts [equation (XII.10)] which is, in turn, a function of the mortgage yield.

Total household liquid assets enters as a determinant in the nonauto consumer durables equation. It has an equation form similar to that of the money stock, except it uses personal consumption expenditures as the transactions variable. It also uses the differential between the long-term bond yield and the savings and loan rate to represent the opportunity cost of holding these assets [equation (XII.11)].

Free reserves

$$(XII.1) \quad RESF = RESNB - (RMBD \cdot RRD \cdot DD + RMBT \cdot RRT \cdot TD)$$

Boundary condition on free reserves

$$RESF/RESNB_{-1} \geq -.0341 + .1674 (RESF/RESNB)_{-1}$$

If inequality is not satisfied, RESF is set so that the equality holds and financial model is solved with equations (XII.3a) and (XII.7a) in place of (XII.3) and (XII.7) and equation (XII.2) is omitted.

Treasury bill rate

$$(XII.2) \quad RTB-RDIS = \underset{(4.7)}{-.374} - \underset{(5.8)}{.533} RESF + .0393 (IIDOL-IVA)$$

$$\underset{(3.9)}{-12.1} (FBF/GNP)_{-1}$$

$$\bar{R}^2 = .611, \overline{SEE} = .23, DW = 1.30$$

Demand for money

$$(XII.3) \quad \log [(DD+CURR)/GNP] = \underset{(55.2)}{-.4040} - \underset{(7.7)}{.469} [\log GNP - \log \overline{GNP}_{-1:4}]$$

$$\underset{(5.7)}{-.0407} \sum_0^2 w_i \log RS_{-i} - \underset{(2.8)}{.102} \sum_0^2 w_i \log RTD_{-i}$$

$$\underset{(7.0)}{-.00247} T531 + .86 \hat{u}_{-1}$$

<u>i</u>	<u>w</u>
----------	----------

0	.6
---	----

1	.3
---	----

2	.1
---	----

Σ	1.0
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$$\bar{R}^2 = .999, \overline{SEE} = .0024, SE.N(DD) = .86$$

$$DW = 1.23$$

Demand for money (alternate equation normalized on RS)

$$(XII.3a) \quad \log (RS/RS_u) = -7.859 \log [(DD+CURR)/(DD_u+CURR)] \\ + 7.859 \log (GNP/GNP_u)$$

where the subscript u denotes unconstrained value
derived from the regression:

$$\log RS = -2.9997 - 7.859 \log (DD+CURR)/GNP$$

$$- \sum_0^2 w_i \log RTD_i - .01299 T531 + .83 \hat{u}_{-1}$$

<u>i</u>	<u>w</u>
0	.6
1	.3
2	.1

$$\Sigma \quad 1.0$$

$$\bar{R}^2 = .913, \quad \overline{SEE} = .05, \quad DW = 1.31$$

Demand for currency

$$(XII.4) \quad \Delta \log [CURR/(PC \cdot C)] = \underset{(7.7)}{-.567} \Delta \left[\log (PC \cdot C) - \log (\overline{PC \cdot C})_{-1:4} \right] \\ - \underset{(11.0)}{.00299} \Delta T531$$

$$\bar{R}^2 = .999, \quad \overline{SEE} = .00215, \quad SE.N(CURR) = .16, \quad DW = .54$$

Time deposits

$$(XII.5) \quad \log TD = \underset{(.63)}{-.1028} + \underset{(1.1)}{.105} \log DPI - \underset{(6.0)}{.0325} \log (RTB/RTD) \\ - \underset{(2.3)}{.0671} \log (RSL/RTD) + \underset{(1.8)}{.925} \log TD_{-1} + .71 \hat{u}_{-1}$$

$$\bar{R}^2 = .9998, \overline{SEE} = .0030, SE.N(TD) = .91, DW = 2.04$$

Interest rate on 4-6 month commercial paper

$$(XII.6) \quad RS = .455 + \underset{(19.1)}{.734} RTB + \underset{(8.7)}{.339} RTB_{-1} - \underset{(4.0)}{.181} DRS$$

$$\bar{R}^2 = .989, \overline{SEE} = .13, DW = .92$$

Interest rate on time deposits

$$(XII.7) \quad RTD = \underset{(1.6)}{-.1403} - \underset{(1.6)}{.166} \left[(RESF/RESNB) + 2.0 (RESF/RESNB)_{-1} \right. \\ \left. + (RESF/RESNB)_{-2} \right] + \underset{(3.5)}{.103} RTQ + \underset{(52.3)}{.944} RTD_{-1}$$

$$\bar{R}^2 = .997, \overline{SEE} = .05, DW = 1.49$$

Alternative used when free reserves are under boundary constraint

$$(XII.7a) \quad RTD = \underset{(1.6)}{-.1403} - \underset{(1.6)}{.166} \left[(RESF_u/RESNB) + 2.0 (RESF_u/RESNB)_{-1} \right. \\ \left. + (RESF_u/RESNB)_{-2} \right] + \underset{(3.5)}{.103} RTQ + \underset{(52.3)}{.944} RTD_{-1}$$

Average bond yield

$$(XII.8) \quad RL-RS = .0929 - \underset{(20.8)}{.673} RS + \underset{(18.8)}{.677} RS_{-1} + \underset{(27.0)}{1.13} (RL-RS)_{-1} \\ - \underset{(5.3)}{.216} (RL-RS)_{-2}$$

$$\bar{R}^2 = .979, \overline{SEE} = .09, DW = 2.10$$

Mortgage yield

$$(XII.9) \quad RM = 1.41 + .305 RL + .531 RM_{-1} + .62 \hat{u}_{-1}$$

(3.4) (5.4)

$$\bar{R}^2 = .985, \overline{SEE} = .06, DW = 1.68$$

Average interest rate on savings and loan accounts

$$(XII.10) \quad \Delta RSL = .0162 + .192 \Delta RM + .373 \Delta RSL_{-1}$$

(5.3) (3.9)

$$\bar{R}^2 = .496, \overline{SEE} = .029, DW = 2.37$$

Liquid assets held by households

$$(XII.11) \quad \log [LH/(PC \cdot C)] = -.2118 - .652 \left[\log (PC \cdot C) \right. \\ (13.7) \quad (6.6) \\ \left. + \log (\overline{PC \cdot C})_{-1:4} \right] + .00279 T531 \\ (9.6) \\ - .216 \sum_0^3 w_i \log (RL/RSL)_{-i} + .91 \hat{u}_{-1} \\ (4.8)$$

<u>i</u>	<u>w</u>
0	.346
1	.300
2	.227
3	.127
Σ	1.000

$$\bar{R}^2 = .996, \overline{SEE} = .0027, SE.N(LH) = 1.75 \\ DW = 1.37$$

XII. Definitions of Symbols

C	Personal consumption expenditures, billions of 1958 dollars
CURR	Currency outside banks, daily average of quarter, billions of dollars
DD	Demand deposits, adjusted daily average of quarter, billions of dollars
DPI	Disposable personal income, billions of dollars
*DRS	Dummy for introduction of certificates of deposit: 1962-II and after = 1.0; otherwise = 0.0
FBF	Federal surplus or deficit (minus), NIA basis, billions of dollars
GNP	Gross national product, billions of dollars
IIDOL	Change in business inventories, billions of dollars
IVA	Inventory valuation adjustment, billions of dollars
LH	Liquid assets held by households at end of quarter (currency plus demand and bank savings deposits plus savings and loan shares), billions of dollars
PC	Implicit price deflator, personal consumption expenditures, 1958 = 1.000
*RDIS	Federal Reserve discount rate, percent
RESF	Free reserves, daily average of quarter, billions of dollars
*RESNB	Nonborrowed reserves, daily average of quarter, billions of dollars
RL	Corporate bond yield (Moody's), percent
RM	Secondary market yield on FHA-insured mortgages, percent
*RMBD	Ratio of Federal Reserve member bank demand deposits to money supply component of demand deposits, decimal
*RMBT	Ratio of Federal Reserve member bank time deposits to total time deposits, decimal
*RRD	Average reserve requirement against member bank demand deposits, decimal
*RRT	Average reserve requirement against member bank time and savings deposits, decimal

RS	Average yield on 4-6 month commercial paper, percent
RSL	Interest rate paid on Savings and Loan Association deposits, percent
RTB	Three-month Treasury bill rate, new issues, percent
RTD	Interest rate on commercial bank savings deposits, percent
*RTQ	Maximum interest rate on Federal Reserve member bank savings deposits under Regulation Q, percent
TD	Time deposits, commercial banks, billions of dollars
*T531	Time in quarters, 1953-I = 1.0

*exogenous

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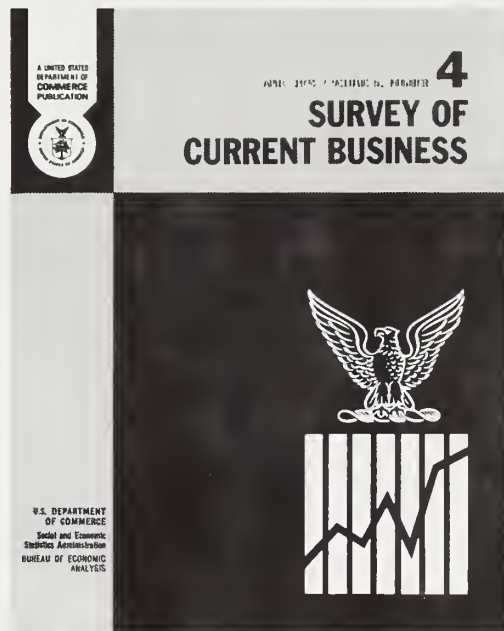
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